Sport and leisure-time physical activity behavior over the life course: Description and explanation of factors and events of individual trajectories

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Abstract

Practicing regular leisure-time physical activity (LTPA) is associated with various health benefits. Thus, from an individual and societal perspective promoting as long-lasting a LTPA behavior as possible is desirable. A life course approach helps to describe and explain such a behavior in the long-term. However, longitudinal studies examining this object of investigation are sparse and little is known about influencing factors for LTPA trajectories over one's life. For this purpose, a retrospective quantitative analysis of almost 2,000 life courses of Swiss inhabitants ranging from 16 to 76 years of age was conducted. Therefore, a contemporary understanding of the general life course approach with guiding principles and additional, more specific theories enriched with sophisticated statistical methods was used. Our data show that LTPA trajectories over the life course with and without transitions (e.g., dropout of LTPA) regarding socioeconomic factors and the LTPA behavior earlier in the life course vary only to some extent. For instance, being active in a self-organized setting already in early years, helps to maintain lifelong activity without interruptions. Furthermore, the youth as an important socializing stage for later behavior in life seems to be decisive regarding LTPA too: various patterns of LTPA behavior in youth are related to high levels of LTPA throughout adulthood. While different ways of a rather diverse activity engagement in youth is particularly promising for lifelong activity, being mainly inactive in youth also indicates a lower activity index later in life. Additionally taking other life domains into account, life events from the familial and occupational life domain are related to transitions (taking up and terminating) of LTPA behavior over the life course depending on the timing when an event occurs. In particular, the more life events experienced simultaneously before 45 years the more likely to terminate LTPA, whereas the contrary effect occurs after 45 years with a higher chance for taking up LTPA. In summary, by using the life course approach, different types of time-related dependencies for LTPA behavior over the life course were shown and other life events outside the leisure life domain are linked to transitions in LTPA behavior. Further and more concrete theories support the description and explanation of the findings mentioned. Additionally, the analysis methods used represented the phenomenon statistically as adequately as possible. Consequently, this thesis extends the understanding of LTPA behavior over the life course with its factors and events from which implications for future research as well as the LTPA and related health promotion can be derived.

The following papers are submitted for the cumulative dissertation:

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Content

List of abbreviations

BASPO	Federal Office of Sport (Bundesamt für Sport)
CATI	Computer-assisted telephone interview
FSO	Federal Statistical Office (Bundesamt für Statistik)
GEE	General estimations equations
LTPA	Leisure-time physical activity
PE	Physical education
RQ	Research question
WHO	World Health Organization

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1 Introduction

In its broad understanding, sport and its various forms fulfill a wide range of important societal functions. For example, success at sport mega events (e.g., Olympic Games) can promote the population's sense of belonging to their own countries (e.g., Elling, van Hilvoorde, & van den Dool, 2014; Hallmann, Breuer, & Kühnereich, 2013). Sport has the potential to encourage social integration (e.g., Elling, de Knop, & Knoppers, 2001; Spaaij et al., 2019), and engaging in sport and related leisure-time physical activity (LTPA[1]) promotes health (e.g., Abu-Omar & Rütten, 2008; Downward, Dawson, & Mills, 2016). Considering the three dimensions of health (physical, mental, and social) according to the World Health Organization (WHO, 1946), LTPA can contribute to each dimension: (1) through the bodily movement component of LTPA, a preventive effect for many non-communicable diseases and a lowered mortality risk are widely acknowledged (e.g., Warburton & Bredin, 2017); (2) LTPA can foster mental health and can reduce the risk for mental ill-health (e.g., White et al., 2017); and (3) the social health benefits of LTPA arise, for example, from the social nature of club-based or team-based sport (Eime, Young, Harvey, Charity, & Payne, 2013a, 2013b). In addition, the long-term effects of LTPA on health are evident (Reiner, Niermann, Jekauc, & Woll, 2013). All the health-promoting benefits of LTPA mentioned are related to an additional aspect relevant to society: health costs. The economic burden of physical inactivity worldwide is conservatively estimated to be over 67 billion dollars per year (Ding al., 2016), and in Switzerland, it is estimated to be over 1 billion Swiss francs per year (Mattli et al., 2014). In conclusion, engaging in sport and practicing LTPA is desirable from multiple perspectives; however, not everyone receives these benefits due to a lack of activity. For example, 25% of the Swiss population is not regularly active (Lamprecht, Bürgi, & Stamm, 2020), and this percentage is much higher in other countries (European Commission, 2018).

Thus, many people are insufficiently active despite large efforts at the political level to promote regular LTPA. Globally, early endeavors began with the EU Charter "Sport for All" in 1975 and the current "Global action plan on physical activity 2018-2030", which targets promoting LTPA in many areas (WHO, 2018). In Switzerland too, there are efforts to implement the WHO strategy (see Stamm, Fischer, & Mathis, 2021), for which one important target group is Switzerland's youth (cf. WHO, 2018). In 2011, the Swiss Federal Assembly passed a law to promote sport and physical activity ("Sportförderungsgesetz"), which includes the provision of three hours of physical education (PE) classes in schools, among others. One goal of PE class is the promotion of short-term and lifelong LTPA (e.g., Green, 2014). Moreover, the nationwide program Youth+Sport is supported by the state with 100 million Swiss francs per year for more than 600,000 Swiss youth (BASPO, 2022). As the Swiss Sport Minister, Viola Amherd, stated

[1]LTPA is defined in this thesis as individually practiced physical activities and sport according to Khan et al. (2012), who distinguish between four types of physical activity: occupational, transport, domestic, and leisure time, where the latter includes exercise, sport, and unstructured recreation. Consequently, e.g., gardening does not count as LTPA in this study (domestic physical activity), but walking (with your dog) or cycling in your leisure time (and not as a transport respective commuting activity) counts as LTPA. Furthermore, in German, the term "sport" refers not only to organized activities but also to informal activities, such as cycling or walking/hiking in leisure. Thus, in Switzerland, sport is understood to be a broad term, and it includes LTPA.

at the press conference of the 50th anniversary of Youth+Sport, practicing sport and LTPA in youth, such as in the Youth+Sport program, "is the foundation for lifelong activity" (BASPO, 2022, p. 2). In addition to supporting youth in engaging in LTPA, provisions in other life stages are also present but less directly supported by politics. For example, to manage and combine (new) life situations in adulthood, there are gymnastic classes for parents and children to participate in together ("Muki-Turnen"), activities at work provided by employers (e.g., bootcamp during lunch time, fitness room in the building, etc.), and recreation for older people (e.g., "Seniorenturnen").

Changing the focus from policies and provisions that promote LTPA to research, several scientifically supported recommendations can be derived (e.g., Trost, Blair, & Khan, 2014; Milton et al., 2021). These recommendations are based on scientific work, especially on reviews or meta-analyses consisting of empirical studies. To acquire knowledge from empirical studies in this field of research, there are at least two different approaches (Thiese, 2014; Twisk, 2013):

(1) Interventional studies in which the intended effect is actively manipulated, and the outcomes are measured to obtain insights into whether an intervention is functioning, which can have implications for real-world interventions or programs.

(2) Observational studies, where a phenomenon in the real world is observed, and data are generated related to the phenomenon. Researchers can describe and explain the phenomenon and certain relationships within it. Furthermore, it is possible to predict certain outcomes. This approach does not actively manipulate anything but rather represents the real world using specific methods. Consequently, results from such studies can have implications to change or promote current programs, offerings, or behaviors of the population or subgroups thereof.

In sum, promoting sport and LTPA are related to various benefits on the individual and societal levels. Primarily, the positive health-related effects through practicing LTPA, whether regular and long-lasting (Reiner et al., 2013) and especially lifelong activity, are particularly desirable. Consequently, investigations considering this perspective are necessary. Thus, the life course approach (e.g., Bernardi, Huinink, Settersten, 2019) is suitable for this long-term perspective. When adequately describing and understanding LTPA over a long period or over the life course, an enormous number of interdependencies in life exist, such as between earlier and current experiences or between different life domains (Bernardi et al., 2019; Li, Cardinal, & Settersten, 2009). One major challenge is that LTPA behavior over the life course has a low stability, and thus changes occur (Malina, 2001; Telama, 2009). Therefore, strategies are required to foster active and stable behaviors and to facilitate engaging in LTPA again after a less active or inactive period. The aim is to examine relevant factors and events to derive such strategies under the perspective of the aforementioned life course approach. For example, the LTPA experiences in youth are indicative of further LTPA behavior over the life course (e.g., Hirvensalo & Lintunen, 2011; Kirk, 2005), and events in other life domains are related to changes in LTPA behavior (e.g., Gropper, John, Sudeck, & Thiel, 2020); however, there is sparse research on LTPA that focuses on interdependencies over a long period or throughout the life course (cf. Hirvensalo & Lintunen, 2011; Yingwattanakul & Moschis, 2017).

Thus, this thesis investigates LTPA over the life course by retrospectively examining life course data from individuals. In addition to LTPA data, information related to the family, education, and occupations is also included to better understand their association with LTPA from the life course perspective.

Regarding the two approaches mentioned to obtain knowledge from empirical studies, the thesis followed the second approach by examining and observing life courses in the real world rather than actively manipulating specific effects (e.g., treatment or intervention). The object of investigation is individual behaviors related to the context.

Accordingly, the following general research question was derived:

What factors and events describe and explain LTPA behavior over the life course?

2 Conceptual background of the thesis

2.1 Human development over the life course

There are different research approaches used to understand how individuals develop over a long period of time or over the life course. Life course research therefore provides one general suitable theoretical approach. The origin of our understanding of life course research mainly dates back to two approaches: life span psychology (e.g., Baltes, Lindenberger, & Staudinger, 1998) and life course sociology (e.g., Elder, Johnson, & Crosnoe, 2003). Whereas lifespan psychologists are more likely to focus on the internal development of individuals (e.g., psychological functioning, self-regulation, etc.), life course sociologists place the person in the broader context of social conditions, institutions, and history (see Diewald & Mayer, 2009, for a discussion). In principle, considering the different levels of analysis, these two approaches seem difficult to make commensurable. Even in life course sociology, one unified theory is lacking. Instead, there is an emerging consensus of criteria (Mayer, 2009) or general paradigmatic principles (Elder et al., 2003). Three of these criteria, respectively principles, are described below and are authoritative for this thesis (derived from Elder et al., 2003; Mayer, 2009):

1. Human lives are viewed not as single life stages but as a lifelong process, where early experiences influence later outcomes in life.
2. Life domains (e.g., family, work, leisure, etc.) are interdependent; human lives in one domain cannot be fully understood without considering other life domains.
3. Depending on the timing of events or experiences, they can affect individuals in different ways.

To follow these general assumptions, which are also relevant in life span psychology, and to outline human development over a long period, integrative and interdisciplinary approaches are necessary (e.g., Conzelmann, 2001; Diewald & Mayer, 2009; Levy, Ghisletta, Le Goff, Spini, & Widmer, 2005). Such integrative and interdisciplinary approaches have increasingly evolved. From a more psychological background and not originating from the classical life course research, so-called developmental science was established in 1987 with the *Carolina Consortium on Human Development*. It integrates not only psychological but also sociological and biological aspects (Cairns, Elder, & Costello, 1996) and meanwhile further developed into the Relational-Developmental-Systems Approach (e.g., Lerner, 2006; Overton, 2015). The already introduced life course approach was developed even more in an integrative direction, leading to the *Life Course Cube* (Bernardi et al., 2019). Both approaches have the same concept of “human,” and they attribute an active role to individuals but also consider different levels of the environment as having influential roles and thus provide a holistic picture. The continuous interplay between the individual and the environment for the development over the life course is in general referred to as "individual-context-relations" by developmental scientists (Lerner, 2006), whereas the life course researcher emphasize all the interdependencies within and between different levels (“inner individual,” “individual action,” and “supra-individual”),

different life domains, and over time (Bernardi et al., 2019). This thesis can be positioned in both research streams. Because the focus here is explicitly on the entire life course and the individual behaviors related to the social and physical contexts (not psychological, biological, or even epigenetical processes), the life course approach is used as the theoretical foundation; however, as emphasized, the life course approach cannot be described as a theory. It is more a dynamic system with basic mechanisms or building blocks with individual behaviors at the center (Bernardi et al., 2019; Overton (2015) would call it a "metatheory"). It is exactly this non-specificity that calls for complementary theories (Bernardi et al., 2019; see also Overton, 2015). Therefore, further theories are beneficial to this thesis, which partly stem from developmental science, among other fields. To illustrate the current understanding of life course research, Figure 1 shows the aforementioned *Life Course Cube*.

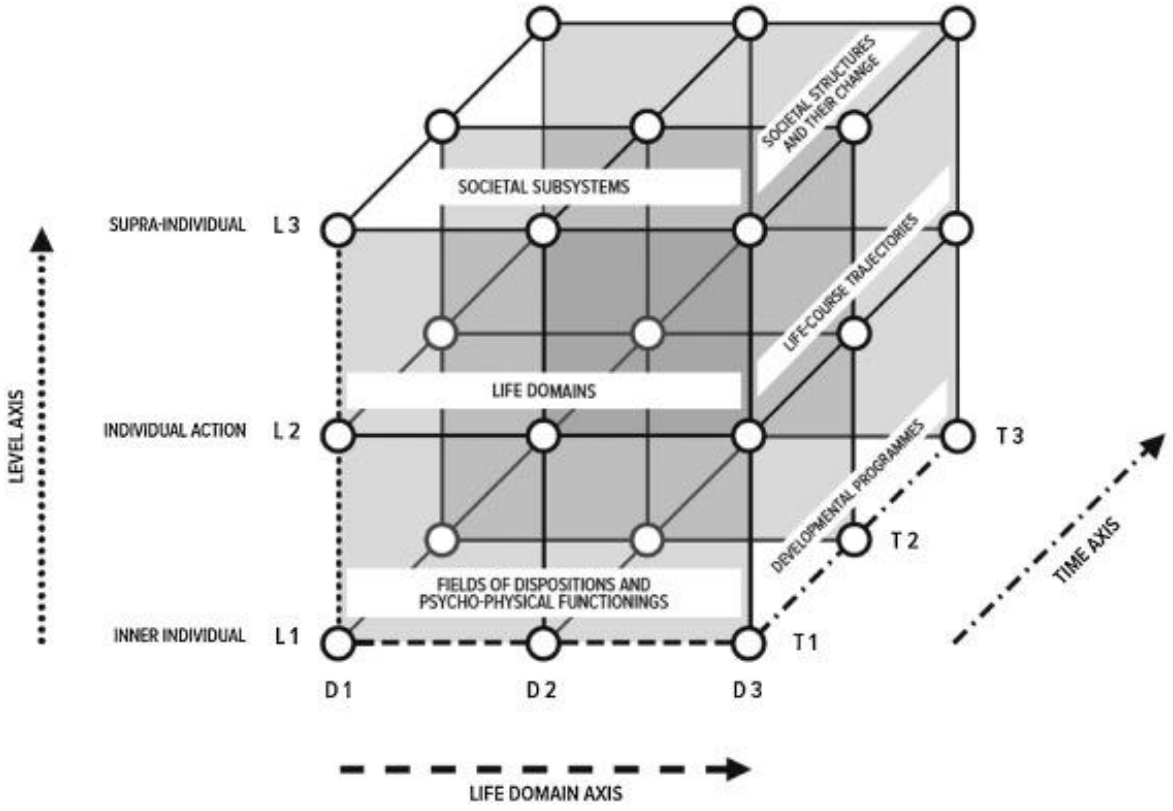

Figure 1. The *Life Course Cube* (Bernardi et al., 2019; figure from Bernardi et al., 2019, p. 4, https://www.sciencedirect.com/science/article/pii/S1040260818301850#fig0005, CC BY 4.0 https://creativecommons.org/licenses/by/4.0/).

The general definition of the life course is a "multifaceted process of individual behavior" (Bernardi et al., 2019, p. 2) in the complex mesh of the three axes and their interdependencies. Therefore, individual behaviors extend over different life domains induced by and actively influencing inner individual conditions and resources and are embedded in socio-cultural environments. This attempt at a definition is not at all complete. Bernardi and colleagues (2019) describe further different interdependencies in the *Life Course Cube*: first-, second-, and third-order interdependencies. The first-order interdependencies related to the respective axis are *time-related interdependence of the life course*, *interdependence between life domains*, and *multilevel interdependence of the life course*, whereas second- and third-order

interdependencies combine multiple axes (Bernardi et al., 2019, p. 3; see Bernardi et al., 2019, for a detailed explanation). One example of a second-order interdependency is described in the discussion between Mayer and Bernardi and colleagues. Mayer (2019) criticizes the handling of time insofar as different domain-specific time clocks and the historical time are not considered. Bernardi, Hunink, and Settersten (2020) argue that these time dimensions are included in second-order interdependencies, meaning that the dimensioning of time can depend on the interdependencies with the respective life domain or the supra-individual level (see Bernardi et al., 2020, for a detailed explanation).

Regarding the three authoritative principles of life course research for this thesis, they can be classified in the *Life Course Cube* (Bernardi et al., 2019) with the complementing explanations regarding time (Bernardi et al., 2020; see Table 1).

Table 1. The three authoritative principles for this thesis in life course sociology (left row) and the integration in the recent Life Course Cube (right row).

Authoritative principles of life course research for this thesis (derived from Elder et al., 2003, and Mayer, 2009)	*Classification of the understanding of the Life Course Cube (Bernardi et al., 2019, 2020)*
1. Human lives are viewed not as single life stages but as a lifelong process, where early experiences influence later outcomes in life.	Path dependency means that not only the recent past but also the far-away past influences the present. In other words, the time-related dependencies over the life course can also be considered an endogenous causal system (introduced by Mayer, 1990).
2. Life domains (e.g., family, work, leisure, etc.) are interdependent; human lives in one domain cannot be fully understood without considering other life domains.	This aspect is directly reflected by the domain axis and is well-displayed with the connection to other areas of the cube. Individual resources are needed to perform an activity in one life domain. Thus, life domains compete, compensate for, or substitute resources (cf. Diewald, 2003, 2012). If activities in one life domain influence other life domains, there are spillover effects.
3. Depending on the timing of events or experiences, they can affect individuals in different ways.	It is argued that "life domains have and also impose different calendars for transitions" (Bernardi et al., 2019, p. 7), which leads to second-order interdependencies (time axis and life domain axis) or even third-order interdependencies (all three axes; see chapter 2 in Bernardi et al., 2020). Consequently, depending on the life domain and individuals' own time clocks, as an extension of the aforementioned second principle, events and experiences in one life domain can influence – depending on the timing and "matching" of the respective time clocks – other life domains.

In summary, the guiding principle of life course research for this thesis can be integrated into the *Life Course Cube*. Consequently, the recent *Life Course Cube* helps to classify the older principles systematically to make the relations between these principles visible and to provide a starting point for the more specific theories suggested.

2.2 Life course research in sport and leisure-time physical activity

Focusing on sport and related LTPA in terms of the *Life Course Cube* involves taking the leisure life domain into account where LTPA is embedded. In addition, including the time respective to the life course as the overarching understanding of time, Bernardi et al. (2019, 2020) discussed term this second-order interdependencies (one life domain and time axis: "path-dependencies", Bernardi et al., 2020, p. 2). Furthermore, the emphasis regarding the level axis is on the individual action leading to the analysis of LTPA behaviors over the life course, which one would consider third-order interdependencies according to Bernardi et al. (2019). This focus is necessary because it is impossible to test all interdependencies over the life course simultaneously (Bernardi et al., 2019). As can be derived from the *Life Course Cube*, the analysis of LTPA behaviors over the life course is also dependent on other areas of the cube, such as from other life domains. This extension of the mentioned focus is addressed later in this thesis (see chapter 2.2.2).

The tradition in sport science of researching sport and LTPA over the life course began with Baur (1989), who developed a dialectic-interactionistic framework to analyze careers of bodies and physical activity (German: "Körper- und Bewegungskarrieren"), emphasizing the personality as the driver of development (Baur, 1989). Later, Conzelmann (2001) merged different disciplines (life course research, lifespan psychology, and developmental science) to build an interdisciplinary approach for analyzing life courses, focusing on sport and personality development mainly of former Olympic athletes. Nagel (2002) extended the research field by emphasizing the environmental perspective when investigating vocational careers in relation to the sporting careers of former Olympic athletes; however, the participation in sport and LTPA from a life course perspective later came to the fore, such as with investigations from Germany (Allmer, 2002; Breuer, 2003, 2004; Klein, 2009; Klostermann, 2012; Pahmeier, 2008; Woll, 2006), Ireland (Lunn, 2010), the Netherlands (e.g., Kraaykamp, Oldenkamp, & Breedveld, 2012), and Belgium (e.g., Borgers, Vanreusel, Lefevre, & Scheerder, 2018; Scheerder et al., 2006).

Another research stream with a life course perspective has developed from a more general physical activity approach, including the three authoritative principles used for this thesis (Li et al., 2009; see also Corder, Ogilvie, & van Sluijs, 2009), from a health-related background with life course epidemiology (Kuh, 2007).

Hirvensalo and Lintunen (2011) combined "sports traditionalists" and health-oriented, physical activity research to summarize the state of research on participation in sport and physical activity over the life course. Therefore, and considering the systematology of the *Life Course Cube*, two general topics can be identified: (1) physical activity behavior over the life course

and its correlates within the leisure life domain and (2) transitions and events from other life domains affecting LTPA over the life course.

2.2.1 LTPA over the life course and its correlates within the leisure life domain

Investigating the course of LTPA is linked to the first principle of this thesis, taking lifelong processes (first part of principle 1) and time-related dependencies over the life course (second part of principle 1) into account.

2.2.1.1 Describing different types of trajectories of LTPA behavior over the life course

When initially considering LTPA behavior as a lifelong process (first part of principle 1), the trajectory of LTPA in the general population is typically characterized by an active childhood and youth with a decline or plateau in early adulthood. The state of research remains contradictory to the direction in which LTPA behavior further develops. Some found a decline (Breuer, 2004; Lunn, 2010), others stability (Klostermann & Nagel, 2011), and still others an increase (Klein, 2009), which also depends on sex, educational level, and birth cohort (Breuer, 2003; Breuer & Wicker, 2009; Klostermann & Nagel, 2011). Recently, a more differentiated approach has been taken by identifying homogeneous subgroups in the heterogeneous population of LTPA-trajectories with so-called finite mixture modeling. Three to four distinct trajectories are normally observed, indicating that one overall trajectory of LTPA over the life course does not adequately describe LTPA behavior over the life course in the population, which implies inter-individual differences (Lounassalo et al., 2019). In addition to describing the trajectory of LTPA behavior over the life course, the differentiation between leisure-time physical inactivity and regular LTPA is crucial from a health-related perspective. More precisely, "in order to improve health, the first decision (whether or not to participate) is much more important that the second (the amount)" (de Boer, 2022, pp. 109-110). The significant health effect of being at least low active compared to inactive is also shown by other studies (e.g., Arem et al., 2015, for mortality; Hamer, Stamatakis, & Steptoe, 2009, for mental health; Sattelmair et al., 2011, for coronary heart disease). Therefore, episodes of inactivity over the life course should be avoided, whereas regular active episodes should be promoted or maintained. Based on such activity-inactivity episodes over the life course (Allmer, 2002; Engel & Nagel, 2011) and thus gradually moving on to time-related dependencies (second part of principle 1), the longer the active episode, the lower the risk to dropout with a decreasing risk to dropout with each further active episode over the life course (Engel & Nagel, 2011); however, factors explaining entries into and exits from active episodes are difficult to identify within the leisure life domain and could be partly explained by socio-demographic variables (Engel & Nagel, 2011; Jekauc, Wäsche, Mess, Bös, K., & Woll, A., 2018)[2]. Consequently, investigating activity and inactivity episodes over the life course in the future can contribute to a better understanding of this mechanism and to deriving implications for health policies.

[2]Factors that are related to transitions of LTPA occur in other life domains, which are described in chapter 2.2.2.

2.2.1.2 Time-related dependencies of LTPA behavior over the life course

Stability

Continuing with time-related dependencies or path dependencies over the life course (Bernardi et al., 2019) based on the first principle of this thesis, the most basic form is investigating the stability, or "tracking" (cf. Malina, 2001), of LTPA behavior over the life course. As can be expected based on information related to trajectories and activity-inactivity episodes, the stability of LTPA behavior over the life course is rather low and declines with a longer period of investigation, whereas inactivity tracks more stable than activity (Hirvensalo & Lintunen, 2011; Malina, 2001; Telama, 2009).

Predictors

Another aspect of time-related dependencies over the life course are predictors, which can forecast LTPA behavior based on certain variables. In particular, the early years of life are therefore under investigation because youth is viewed as a window of opportunity to shape subsequent developmental trajectories over the life course (Dahl, Allen, Wilbrecht, & Suleiman, 2018), including health-related behaviors in general (Sawyer, Afifi, Bearinger et al., 2012) and LTPA behaviors (cf. Kirk, 2005). Commonly researched predictors of LTPA in youth, which are positively related to LTPA later in life, are an early entry age (Kjønniksen, Anderssen, & Wold, 2009; Yang, Telama, Leino, & Viikari, 1999); persistent exercising of at least three years (Bélanger et al., 2015; Kjønniksen et al., 2009; Palomäki et al., 2018; Scheerder et al., 2006; Telama, Yang, Hirvensalo, & Raitakari, 2006; Telama et al., 2005; Telama, Yang, Laakso, & Viikari, 1997); frequency of exercise (Engström, 2008; Murphy, Rowe, & Woods, 2016; Perkins, Jacos, Parker, & Eccles, 2004; Scheerder et al., 2006; Smith, Gardner, Aggio, & Hamer, 2015; Tammelin, Näyha, Hills, & Järvelin, 2003; Telama et al., 2006; Vanreusel et al., 1997); the organizational setting, which is often measured only as organized or club sports (Barnekow-Bergkvist, Hedberg, Janlert, & Jansson, 1996; Engström, 2008; Gil de Montes, Arruza, Arribas, Irazusta, & Telletxea, 2011; Kraut, Melamed, Gofer, & Froom, 2003; Perkins et al., 2004; Richards, William, Poulton, & Reeder, 2007; Telama et al., 1997; Trudeau, Laurencelle, & Shepard, 2003, for men) but is also considered to include self- or non-organized activities (Cleland, Dwyer, & Venn, 2012; Scheerder et al., 2006); competitive sports (Gil de Montes et al., 2011; Hirvensalo, Lintunen, & Rantanen, 2000; Kujala, Sarna, Kaprio, Tikkanen, & Koskenvuo, 2000; Mäkinen et al., 2010 if low educated; Murphy et al., 2016; Telama et al., 1997; Telama et al., 2006); skills (Taylor, Blair, Cummings et al., 1999), abilities (Kuh & Cooper, 1992) and fitness level (Barnekow-Bergkvist et al., 1996); the number of different activities (Engström, 2008; Kjønniksen, Torsheim, & Wold, 2008; Mäkela, Aaltonen, Korhonen, Rose, & Kaprio, 2017 for women; Scheerder et al., 2006); and specific types of activities (Kjønniksen et al., 2008; Tammelin et al., 2003). In addition to tracking, taking such predictors into account extend the understanding of time-related dependencies over the life

course regarding LTPA behavior; however, most of the studies mentioned do not consider a life course approach but rather compare these predictors in youth with physical activity or LTPA levels in (young) adulthood to one or few measurement points.

Relational-Developmental-Systems Approach for LTPA

Another criticism of such predictors can be formulated based on the current understanding of human development, enriching the life course approach with a more specific theory. Based on the already introduced *Relational-Developmental-Systems Approach* from developmental science (see chapter 2.1), the adaptation to LTPA means that individuals with their characteristics choose environments to participate in LTPAs in specific contexts (see Agans, Säfvenbom, Davis, Bowers, & Lerner, 2013, for an introduction). Thus, for an individual, there are multiple combinations of activities, and exposure to various contexts is possible (Agans & Geldhof, 2012; Agans et al., 2013). Consequently, there is no singular activity in youth that leads to the conducive development of an individual (Coakley, 2011); however, investigations on LTPA predictors in youth using aggregated data of the sample indicate one solution for the whole sample (cf. Zarrett et al., 2009), which is not suitable for understanding human development because from this understanding of development, activities and contexts are interrelated; thus, interactions within individuals occur (e.g., football can be played in a club or self-organized; cf. Gut, Schmid, & Conzelmann, 2020; Zarrett et al., 2009). More precisely, the impact of one variable depends on the expression of the other variables in such constellations, further indicating that considering separate variables falls short of understanding development as individual-context-relations (cf. Magnusson & Cairns, 1996). Similar to this relative impact of one variable in a constellation, certain mechanisms of variables within constellations can occur. A compensation effect means that high values of certain variables can counterbalance low levels of other variables, whereas a synergistic effect indicates that high levels of certain variables strengthen each other to achieve a developmental outcome (e.g., later LTPA in life). Another argument why separate variables or predictors fall short of describing LTPA behavior and development adequately, are not only the introduced intra-individual differences, but also, as already mentioned for LTPA-trajectories, the differences between individuals. The interplay of the relevant variables, respectively predictors, lead to different combinations and thus different constellations (e.g., some play football in a club, others play self-organized, and others do both; cf. Zarrett et al., 2009). In other words, separate variables of predictors neglect intra- and inter-individual differences in LTPA behavior and development. Investigating constellations or so-called patterns of the relevant variables provides a more holistic picture of the phenomenon; however, research with this understanding of development has so far only focused on describing LTPA patterns in youth regarding sport types (e.g., soccer, tennis, etc.; Borgers et al., 2015; Liu, Sun, Beets, & Probst, 2013), categories of sport types (e.g., individual or team sports; Agans & Geldhof, 2012) together with the organizational setting (Lawler, Heary, & Nixon, 2017), or the organizational and social setting (Gut et al., 2020). Furthermore, in addition to LTPA variables, patterns with motivational (Schmid, Gut, Yanagida, & Conzelmann, 2019) and with social and organizational aspects (Gut, Schmid, Imbach, &

Conzelmann, 2022) were identified and related to exercise adherence in educational transitions. The variables included for a pattern analysis of LTPA are complemented by the breadth of activities (the number of different activities) and the depth of activities (frequency of participation), and patterns with both a high breadth and depth of activities in late youth have shown a slightly higher participation in LTPA in young adulthood (Agans, Johnson, & Lerner, 2017). Moreover, Klostermann and Nagel (2011) included the organizational setting and the depth and breadth of activities but for the first half of life (until 39 years of age) and compared their patterns with the activity in the second half of life.

Overall, there was an attempt to represent LTPA behavior in youth with variables regarding the types of LTPA, the organizational setting, the social context, the motivational aspects, the breadth of activities, and the depth of activities. This approach seems promising to implement the understanding of human development; however, the relationship between such patterns and lifelong LTPA are yet to be examined.

Explanatory approaches

After outlining the aspects of time-related dependencies of LTPA behavior over the life course, especially emphasizing the role of LTPA in youth for lifelong activity, the question remains regarding the underlying mechanism. Telama (2009) formulated four hypotheses. The *self-selection hypothesis* is more genetically driven and means that individuals possess a disposition to be physically active or not, leading to a stable (either active or inactive) behavior over the life course. The *habit formation hypothesis* states that if one can internalize physical activity behavior as a habit, it remains stable over the life course. The *carry-over value hypothesis* suggests that the same or at least similar activities practiced in early years are also exercised later in life, known as lifestyle activities (e.g., endurance activities, Tammelin et al., 2003). Lastly, the *ability and readiness hypothesis* reveals that an early, persistent, and broad LTPA engagement helps in maintaining activities and starting new activities later in life due to the various skills and abilities learned. This idea is similar to the already introduced concept of the breadth of activity (Agans et al., 2017; see Agans et al., 2014 for a general discussion) and to the early sampling approach for later recreational sport activity or LTPA (Côté, Baker, & Abernethy, 2007; Wall & Côté, 2007). As the latter two author groups further state, there is not one explanation, respectively way, for lifelong activity in the general population.

In sum, the first authoritative principle of this thesis regarding lifelong processes and time-related dependencies is also applicable to the leisure life domain and related LTPA. Therefore, LTPA behavior over the life course can be described as including a general trajectory, activity-inactivity episodes, and stability, whereas youth is a particularly promising life stage regarding lifelong LTPA described by specific predictors or even patterns, which would be more suitable for the current developmental understanding.

2.2.2 The role of transitions and events from other life domains on LTPA over the life course

As shown in chapter 2.2.1.2, LTPA behavior over the life course has a low stability, and transitions (e.g., dropouts) occur. Regarding the reasons why these transitions occur, an often-cited review of qualitative studies (Allender, Cowburn, & Foster, 2006) highlights a wide range of promoting factors and barriers for participation in sport and physical activity, differing by life stage. There are psychological and social aspects that act as promoters (e.g., enjoyment, peer support) or barriers (e.g., negative experiences at school, lack of role models in adults) as well as structurally promoting (e.g., safe environment for young children) and hindering (e.g., competitive sports) factors. In addition, significant shifts in the life course, such as transitions and life events, affect participation in physical activity and sport (Allender et al., 2006).

2.2.2.1 The relationship between life events and LTPA behavior

Recently, the impact of life events (e.g., becoming a parent, starting a new job) on LTPA has been an often-researched topic (e.g., Allender, Hutchinson, & Foster, 2008; Engberg et al., 2012: Gropper et al., 2020). From a theoretical point of view, this reflects the second authoritative principle of this thesis, meaning that life domains are interdependent and that LTPA (leisure life domain) can be affected by life events from other life domains, which is also known as the spillover effect (Bernardi et al., 2019; see chapter 2.1). Consequently, regarding the *Life Course Cube*, the focus still remains on the individual action level, and for handling the axis "time," the entire life course is considered. In addition to the leisure life domain, other life domains are taken into account. Relevant and often investigated life domains and related life events in combination with LTPA are the familial (e.g., becoming a parent, starting a new relationship), education-related (transitions from one education to another), employment-related (e.g., starting or quitting a job), residential (change in place of residence), and health-related (e.g., diagnosis of an illness) life domains (cf. Allender et al., 2008; Gropper et al., 2020). The impact of life events on LTPA often yields negative consequences (e.g., educational transitions, becoming a parent, entry into the labor market), mixed effects (e.g., job change, changes in relationship, moving), and in the case of retirement, a positive outcome, depending partly on sex (Allender et al., 2008; Barnett, van Sluijs, & Ogilvie, 2012; Corder et al., 2020; Engberg et al., 2012; Gropper et al., 2020; Winpenny et al., 2020). In general, the impact of life events on LTPA seems well-studied; however, the third authoritative principle of this thesis – the relevance of the timing of events – thus far has been neglected in this field of research. The general life course approach (e.g., Elder et al., 2003) assumes that life events lie under social regulations and age-graded norms; however, individuals vary in the pace and sequencing for choosing or experiencing these life events in their life courses (Elder, 1995). Regarding life events related to LTPA behavior, it can be assumed that the impact of life events on changes in LTPA behavior depend on the timing when these events occur, which is theoretically sound (Corder et al., 2009; Li et al., 2009) but not yet empirically studied.

2.2.2.2 Explanatory approaches for the association between life events and LTPA behavior

The reason for the spillover effect lies in adaptation processes using individual resources, which change in different ways after experiencing a life event (Bernardi, Bollmann, Potarca, & Rossier, 2017; Filip & Aymann, 2018). As already discussed for the second principle of this thesis (see Table 1), there are "resource-related issues" (Bernardi et al., 2019, p. 5) for activities between different life domains. More precisely, life domains compete for resources (e.g., conflict of resources for two activities), support or complement each other (e.g., gain resources in one domain that can be used in another domain), or compensate for resources from each other (e.g., resources sought in one life domain can be fulfilled in another life domain; Diewald, 2003; Bernardi et al., 2019; Spini, Bernardi, & Oris, 2017). Regarding LTPA, these individual resources can be divided into temporal and social resources (van Houten, Kraaykamp, & Breedveld, 2017) or are viewed as shifting away from physical activity after experiencing a life event (Nigg, Borrelli, Maddock, & Dishman, 2008). Thus, after experiencing a life event, individual temporal and social resources are reallocated to LTPA and other life domains, which can have different effects on LTPA, as shown by empirical studies. One might conclude that the more life events experienced simultaneously, the more resources are changed or shifted. This theoretical deduction was empirically investigated only once for a physical activity intervention with the expected effect of a higher dropout rate when affected by multiple life events simultaneously (Oman & King, 2000).

In summary, according to the second authoritative principle of this thesis, it becomes evident that different life domains are interdependent and that life events from other life domains affect LTPA merely in a negative manner due to changed or shifted resources outlined in the spillover effect; however, the impact of the timing and the occurrence of multiple life events, described in the third authoritative principle of this thesis, seems theoretically relevant but has not yet been researched.

3 Summary, research gaps, and concluding research questions

With regard to the goal of promoting long-lasting and even lifelong LTPA behavior (cf. chapter 1), the life course approach offers a theoretical foundation to describe and explain LTPA behavior over the life course. The three authoritative principles for this thesis, viewing LTPA as a lifelong process with time-related dependencies (principle 1), interdependencies between life domains (principle 2), and the timing of events or experiences (principle 3), act as guides to investigate LTPA over the life course for this dissertation.

Because LTPA behavior over the life course has a low stability, reasons thereof must be elaborated to understand and explain this behavior from a life course perspective because different factors and events influence LTPA over the life course (see chapter 2.2.1 and 2.2.2). In addition to the discussion on the general research gap of a lack of studies over the life course, including such relevant factors and events (see chapter 1) and taking the three authoritative principles for this thesis into account, more specific research gaps are summarized, and the research questions are presented.

3.1 Research gap and research question 1

As LTPA is a lifelong process (first part of principle 1), episodes of activity and inactivity occur (Allmer, 2002; Engel & Nagel, 2011). This differentiation is highly relevant regarding health aspects (Arem et al., 2015; Hamer et al., 2009; de Boer, 2022; Sattelmair et al., 2011; see chapter 2.2.1.1); however, appending now time-related dependencies as the second part of principle 1, when searching for reasons inducing either stable or unstable behavior and transitions in LTPA over the life course within the leisure life domain, no clear explanation can be provided. It is only known that the longer someone stays in a specific episode, the lower the chance for a transition, and other variables of previous LTPA experiences cannot explain these transitions (Engel & Nagel, 2011). When we extend the perspective to socioeconomic factors, sex, educational level, and age, respectively birth cohort, are related to transitions in LTPA (Engel & Nagel, 2011; Jekauc et al., 2018). In summary, there is no clear evidence of how transitions in LTPA are related to other factors of previous LTPA behavior, and only scarce evidence is given by few socioeconomic variables. It therefore becomes evident that – in line with the authoritative principle 1 – active and inactive episodes over the life course and a differentiation among distinct LTPA trajectories should be investigated to examine their respective socioeconomic variables and previous LTPA behavior.

This leads to the following research question (RQ):

> RQ 1: To what extent is LTPA behavior over the life course described by trajectories of activity-inactivity episodes, and how are these trajectories related to previous LTPA behavior and socioeconomic variables?

3.2 Research gap and research question 2

If we now focus more on the time-related dependencies over the course of life (second part of principle 1), youth is a highly relevant life stage for gaining experiences and learning to shape the further course of life (Dahl et al., 2018; Kirk, 2005; Sawyer et al., 2012). In addition to the low stability of LTPA from youth over the life course, specific predictors of LTPA aspects in youth were found to forecast later LTPA over the life course (see chapter 2.2.1.2); however, studies investigating such predictors have not considered lifelong LTPA as a criterion, and they do not reflect the contemporary understanding of human development based on individual-context relations (Cairns et al., 1996; Lerner, 2006; Overton, 2015; for LTPA: Agans et al., 2013; Zarrett et al., 2009). Investigating separate predictors neglect inter- and intra-individual differences in LTPA behavior in youth and thus provide a less holistic picture than patterns of variables representing LTPA behavior including inter- and intra-individual differences.

Consequently, the second research question of this thesis is as follows:

> RQ 2: Which patterns of LTPA behavior in youth emerge, and to what extent are they associated with lifelong LTPA?

3.3 Research gap and research question 3

Taking principle 2 of this thesis into account, life domains are interdependent, and events or experiences in one life domain can influence other life domains, indicating spillover effects (see Table 1). For LTPA, it means that life events from other life domains can affect LTPA behavior (Allender et al., 2008; Engberg et al., 2012; Gropper et al., 2020). These effects are well-studied for normative life stages (cf. Elder, 1995) regarding the respective life events. Considering the relevance of the timing of events, which reflects principle 3, in addition to normative life stages for respective life events, there are inter-individual differences in the timing of experiencing life events (Elder, 1995). Thus, *when* life events occur in one's life course can evoke different consequences (Corder et al., 2009; Li et al., 2009), which has yet not been empirically investigated.

Furthermore, regarding the assumed reasons for spillover effects, it is possible that individual resources are redistributed after experiencing a life event (see chapter 2.2.2.2). Accordingly, one can assume that the more life events experienced simultaneously, the more resources changed and thus the bigger the effect on LTPA. This assumption has been empirically investigated and supported only once for exercise adherence after an intervention (Oman & King, 2000).

In conclusion, on the one hand, the impact of the timing of life events on LTPA has yet not been investigated, whereas on the other hand, the effect of experiencing multiple life events simultaneously was only tested once in an intervention setting. In addition, the combination of these two aspects has not yet been studied. Therefore, one aim of this thesis is to fill this research gap considering transitions of LTPA (terminating and taking up LTPA) and life events from the familial and occupational life domains based on the following research question:

RQ 3: How are single and multiple simultaneously experienced life events from the familial and occupational life domains related to transitions in LTPA over the life course, and to what extent is the relationship between the life events and transitions of LTPA dependent on the timing of life events?

In sum, this thesis investigates LTPA behavior over the life course with a focus on – mainly within the leisure life domain – (1) activity-inactivity episodes and their correlates and (2) time-related dependencies regarding LTPA behavior patterns in youth and lifelong LTPA, and it extends the perspective by including other life domains to study (3) the role of life events on transitions in LTPA with a focus on experiencing multiple life events simultaneously and the timing of when life events occur.

4 Methodological approach for the thesis

To adequately address the research questions, life course data of individual behaviors in LTPA and the related life domains are required. The thesis is based on one large data set. The general process of data collection and analysis is described in the subsequent chapters. More precise information about the respective research questions is described in the manuscripts (Appendix A, B, and C), which will be referred to in the corresponding passage.

4.1 Design

This thesis is embedded in the project "Sportliche und Körperliche Aktivität im Lebenslauf (SKILL)" funded by the Swiss National Science Foundation. The project is linked to the official Swiss state survey on physical activity and sport participation, "Sport Schweiz," with an additional sample. Data were collected through computer-assisted telephone interviews (CATI-method) in 2019 of n = 2022 Swiss inhabitants. In addition to the general Sport Schweiz survey with questions about current sport and physical activity behaviors, the participants from our sample were asked about their past sport and physical activity behaviors over their life courses. Thus, the approach can be classified as a retrospective observational study (cf. Thiese, 2014, Twisk, 2013). The participants interviewed were between 16 and 76 years of age at the time of the survey. Hence, a broad age range is covered, and multiple age cohorts are included. This extends the definition of the research design to a *multiple cohort, retrospective observational study* (cf. Thiese, 2014, Twisk, 2013).

This design was chosen to collect life course data in an economic way with a retrospective setting compared to a prospective approach; however, the data quality and accuracy are disadvantaged due to the need to trust participants' memories. Consequently, only objective (e.g., entry year into LTPA in the life course) and not subjective (e.g., felt intensity of practiced LTPA) data were gathered, which are better remembered (cf. Ropponen, Levälathi, Simonen, Videman, & Battié, 2001). To support the interviewer and interviewee and for a cost-effective method, the CATI-method was used (cf. Choi, 2004). The following chapter explains how the questionnaire was developed, tested, and optimized in more detail.

4.2 Development and validation of the instrument

As mentioned, collecting valid data in a retrospective design is not, per se, a given. Difficulties concerning the participant's autobiographical memory exist, and therefore the retrieval of past experiences may be influenced. More precisely, the further back in time the past memory is, the more inaccurately and less concrete it is recalled (Bahrick, 1984; Trope & Liberman, 2003). Furthermore, current aspects of the self (e.g., current goals, self-beliefs, etc.) can distort memories (Conway, 2005), or in other words, individuals view the "sense of the past in the light of the present" (Reimer & Matthes 2007, p. 714). Consequently, high demands and caution are required for the instrument. Therefore, considerable efforts were made to collect as reliable and valid data as possible in a multi-stage procedure, including autobiographical assistance,

qualitative and quantitative tests, and interviewer training. The content of the questionnaire is described in manuscript 1 (Appendix A).

The questionnaire used is based on previous studies investigating past experiences in elite level sports (Conzelmann & Nagel, 2003) and LTPA behavior on the population level (Klostermann, 2012). The previous questionnaire already gathered reliable data on LTPA behavior (Klostermann & Nagel, 2011), but the instrument was still refined and further developed because, amongst other adaptations, new items were added regarding life events of the past 15 years in the familial and occupational life domains.

In the first step, multiple cues and pathways were used to support autobiographical memory, such as hierarchical (e.g., from general to specific past LTPA aspects) and sequential (e.g., temporal sequence of past LTPA behavior) pathways (cf. Belli, 1998; Reimer & Matthes, 2007; see manuscript 1 in Appendix A for a detailed description). In the second step, the adapted questionnaire was tested and refined in three rounds. In the first two rounds, qualitative interviews with people of different ages and sexes (1st round $n = 6$; 2nd round $n = 3$) using techniques such as the think-aloud method, confidence rating, and behavior coding were carried out (Dürnberger, Drasch & Matthes, 2011; Moosbrugger & Kelava, 2007). Trained interviewers who also participated later in the main study conducted the 3rd round with $n = 20$ interviews to test the technical and content-related functioning of the questionnaire. Thus, the questionnaire was improved in an iterative process in a theoretical (autobiographical memory) and practical manner. As a third step, a quantitative check was done by conducting a separate test-retest-study to examine the reliability of the final questionnaire. Thus, $n = 29$ participants (17 resp. 59% female; 12 resp. 41% male) ranging from 23 to 75 years of age ($M_{age} = 51.41 \pm 19.09$) were interviewed twice with the final questionnaire 95.07 (± 15.34) days apart on average. Considering different scale levels in the questionnaire, Krippendorff's alpha (Hayes & Krippendorff, 2007) was used for the analysis. The recommended convention for a reliable agreement of the data of $\alpha \geq .80$ (Krippendorff, 2018, p. 356) was fulfilled for all variables except for the frequency of LTPA in all life stages and somewhat for the competition participation of youth (see Table 2).

Table 2. Test-retest reliability values from the entire questionnaire ($n = 29$).

Variable	Scale	Krippendorff's alpha	
		Point estimate	*Bootstrap 95%–CI*[1]
Current LTPA[2]			
Entry age of currently practiced types of LTPA	ratio	.92	.86 – .97
Life events from the familial life domain (last 15 years)			
Number of past relationships	ratio	.90	.77 – 1.00
Timing of relationships (start & end; age)	ratio	.99	.99 – 1.00
Number of children	ratio	1.00	–
Birth year of children	interval	1.00	–
Life events from the occupational life domain (last 15 years)			
Number of vocational trainings	ratio	.92	.77 – 1.00

Cont. Table 2

Timing of vocational trainings (start & end; age)	ratio	.99	.99 – 1.00
Number of jobs	ratio	.96	.91 – 1.00
Timing of jobs (start & end; age)	ratio	.99	.96 – 1.00
Timing of retirement (age)	ratio	.98	.93 – 1.00
Specific aspects of LTPA per life stage			
Youth (until 20 years of age)			
Type of activities practiced	nominal	.95	.89 – .99
Frequency: days per week	ratio	.61*	.38 – .82
Frequency: hours per week	ratio	.61*	.43 – .77
Organizational setting	nominal	.93	.87 – .99
Competition participation	nominal	.73*	.46 – 1.00
Young adulthood (21-30 years of age)			
Type of activities practiced	nominal	.93	.87 – .99
Frequency: days per week	ratio	.52*	.14 – .82
Frequency: hours per week	ratio	.46*	.05 – .78
Organizational setting	nominal	.90	.81 – .97
Competition participation	nominal	.93	.78 – 1.00
Middle adulthood (31+ years of age)			
Type of activities practiced	nominal	.90	.83 – .97
Frequency: days per week	ratio	.45*	.01 – .80
Frequency: hours per week	ratio	.42*	.02 – .77
Organizational setting	nominal	.81	.69 – .93
Competition participation	nominal	1.00	–
Taking up & terminating LTPA in life course			
First time taking up LTPA in life course (age)	ratio	.81	.72 – .89
Interruption(s) of LTPA in life course (yes/no)	nominal	.90	.70 – 1.00
Number of interruptions of LTPA in life course	ratio	.88	.67 – 1.00
Timing of interruptions of LTPA in life course (age)	ratio	.98	.94 – 1.00

[1]As suggested (Hayes & Krippendorff, 2007), 10’000 bootstrap sampling distributions were done (CI = confidence interval).
[2]No other aspect of the current LTPA except the entry age was included in the analysis due to the possible changes between the two interviews three months apart.
*values are below the recommended $\alpha \geq .80$ (Krippendorff, 2018, p. 356)

Consequently, the questionnaire seems to be reliable for a small and similar, regarding age and sex, sample as in the main study, except for mainly aspects of frequency in LTPA. In the fourth step, the CATI-method that the interviewers used can help specifically with memory and comprehension problems. Interviewer training was provided for this purpose. In summary, efforts on different levels were made to support participants in retrieving as accurate memories as possible and thus to collect as valid data as possible.

4.3 Sample

The aim of the investigation to recruit all participants from the representative pool of the Federal Statistical Office (FSO) was not fully reached due to a low participation rate. From the $n = 4538$ persons contacted by conventional mail, for $n = 1777$ persons, no telephone numbers were available, and thus only $n = 819$ interviews were realized from the representative FSO sample. Hence, $n = 1206$ persons were additionally recruited from a non-representative pool but still covering a broad range regarding age, socioeconomic status, and language region. Altogether, $n = 2025$ interviews were conducted with Swiss inhabitants in 2019. After an initial screening, $n = 1939$ participants between 16 and 76 years of age ($mean_{age} = 55.4 \pm 16.3$) from both sexes ($n = 1173$ respective 60.5% female), three language regions (German $n = 1168$; French $n = 574$; Italian $n = 197$), and each educational level (1-5, $mean_{edulevel} = 2.86 \pm 1.25$) remained in the sample. Further checks for internal consistency and plausibility of the data were carefully carried out (see manuscript 1, Appendix A). The samples with detailed characteristics for the respective research question are reported in the manuscripts (Appendix A, B, and C).

4.4 Data analyses

Analyzing longitudinal data provides many advantages (e.g., intra-individual change, predictions, etc.), but researchers also face challenges. For example, handling multiple dimensions and the spacing of time or controlling for confounders, which may explain change over time, should be well-elaborated and already considered before data collection (Ployhart & Vandenberg, 2010; Twisk, 2013). In addition, there is little guidance to find the appropriate method for the given research question and data (Ployhart & Vandenberg, 2010). Regarding the statistical details, the basic assumption of uncorrelated residuals is violated by using multiple data of the same individual over time, and one must find the appropriate variance-covariance-matrix over time (Ployhart & Vandenberg, 2010; Twisk, 2013). Furthermore, to reflect human development with appropriate statistical methods ("theory-method-fit"), classic linear and variable-oriented approaches are no longer the method of choice (Bergman, Magnusson, & El-Khouri, 2003). In summary, more advanced statistical methods are required to fulfill the statistical and theoretical assumptions mentioned and to progress in the understanding and explaining of LTPA over the life course (Li et al., 2009).

For RQ 1 studied in manuscript 1, the most popular form of the survival analysis ("survive" in a given state or episode, for example an episode of practicing regular LTPA), the Kaplan-Meier method (Kaplan & Meier, 1958), was used. Cross tables with chi-square tests and general descriptive values were calculated to describe LTPA trajectories as activity-inactivity episodes (see manuscript 1 in Appendix A for more information).

To analyze RQ 2 in manuscript 2, a person-oriented approach was used to describe human behavior and development as individual-context-relations (e.g., Bergman et al., 2003). Therefore, patterns of LTPA behavior in youth were identified not with a deterministic approach, such as cluster analyses, but with a more advanced probabilistic method, the so-called latent profile analysis (Masyn, 2013). Consequently, homogeneous subgroups, or latent classes,

of the sample regarding LTPA behavior were identified, where each individual relates to subgroups with a certain probability. With these probabilities, associations with the lifelong LTPA were calculated under control for age (McLarnon & O'Neill, 2018; see manuscript 2 in Appendix B for more information).

Given the longitudinal data structure with multiple data and events per individual for RQ 3 and manuscript 3, the already introduced assumption of uncorrelated residuals is violated. To take this non-independent measuring into account, a multi-level approach was used (Hox, Moerbeek, & van de Schoot, 2018), which is also known as mixed models (Twisk, 2013). Hence, the dependency within a person over time is adjusted on an individual level ("subject-specific") and not on a sample level ("population-averaged") compared to other common approaches (e.g., general estimations equations, GEE; Twisk, 2013). By considering these intra-individual dependencies, the impacts of a life event on LTPA transitions were calculated using the event-history analysis method with time-varying (e.g., life event) and time-invariant (e.g., birth cohort) covariates, which can also be called a survival analysis (Allison, 2014). Taken together, multi-level event-history analyses were applied (Steele, 2011; see manuscript 3 in Appendix C for more information).

In summary, advanced statistical analysis methods were used to describe and explain LTPA behavior over the life course adequately while taking the three authoritative principles of this thesis statistically into account. Thus, the high statistical and theoretical demands for analyzing longitudinal and life course data were considered.

5 Classification and summary of the contributions of this thesis

5.1 Manuscript 1

Klostermann, C., Lenze, L., Lamprecht, M., & Nagel, S. (2023). Sport and leisure-time physical activity over the life course. *Current Issues in Sport Science (CISS), 8*(1), 007. https://doi.org/10.36950/2023.1ciss007

The first manuscript deals with the authoritative principle 1 of this thesis by viewing LTPA behavior as a lifelong process and examines time-related dependencies thereof. Thus, LTPA trajectories as activity-inactive episodes from n = 1456 individuals between 35 and 76 years of age were retrospectively studied. To find differences between various LTPA trajectories, socioeconomic information and detailed aspects of LTPA behavior earlier in the life course were integrated (RQ 1; see Figure 2). Therefore, Kaplan-Meier analyses and descriptive methods, including chi-square analyses using cross tabulations, were applied.

LTPA behavior over the life course regarding activity-inactive episodes was relatively stable in this sample, and episodes of activity lasted longer than episodes of inactivity after a transition. Four types of LTPA trajectories were distinguished: *always active early starters* (59.8% of the sample), *always active late starters* (13.3%), *unstable LTPA* (24%), and *never active* (3%). For the group of the *unstable LTPA*, the Kaplan-Meier curve showed that men have a slightly higher risk to dropout earlier from the first active episode than women. The trajectories of the *unstable LTPA* are further characterized by a higher proportion of foreign nationality and stem from the younger age cohort (<56 years). Other socioeconomic differences between the various types of LTPA trajectories are sparsely present: the *always active late starters* contain more older participants and women and are less educated on average, whereas the *never active* are on average more from the older age cohort and less educated. Regarding the detailed aspects of LTPA behavior earlier in their life course, three life stages were distinguished: youth (until 20 years), young adulthood (21-30 years), and middle adulthood (after 30 years). In general, practicing organized activities is preferred in youth, whereas self-organized activities are practiced more often after youth. The most popular activities over all trajectory groups and over the life course are walking and endurance activities as well as outdoor and mountain activities, while sports games in youth are also often practiced and fitness activities become more important from young adulthood. Focusing on differences between the various LTPA trajectories, *always active early starters* are in their youth and also in the other life stages more self-organized in their activities and enter earlier into LTPA compared to the unstable LTPA. In comparison to the *always active late starters*, the *always active early starters* and *unstable LTPA* additionally like to practice sports games in young adulthood.

In summary, LTPA over the life course can be described as activity-inactive episodes, while a large proportion of the sample engaged in LTPA early and stayed active. The differentiation of the four LTPA trajectories revealed only small differences regarding socioeconomic variables: women entered LTPA later in life on average, and participants from the younger cohort are

almost never inactive but show more transitions. The second finding could be explained by the flexibilization of the younger generations and a general time-historical trend towards higher LTPA rates (e.g., Lamprecht et al., 2020). In view of time-related dependencies, it seems that being self-organized active in the early years contributes to staying active throughout life, whereas no further major difference was found regarding detailed aspects of LTPA behavior over the life course. Self-organized activity setting becomes more common in adulthood (Eime, Harvey, & Charity, 2020; Eime et al., 2015), which also supports our data. Thus, starting early within this setting might help to maintain lifelong LTPA.

The investigation of lifelong LTPA trajectories and time-related dependencies (principle 1) extend the description and understanding of specific aspects in LTPA behavior over the life course, such as for the organizational setting or specific activities.

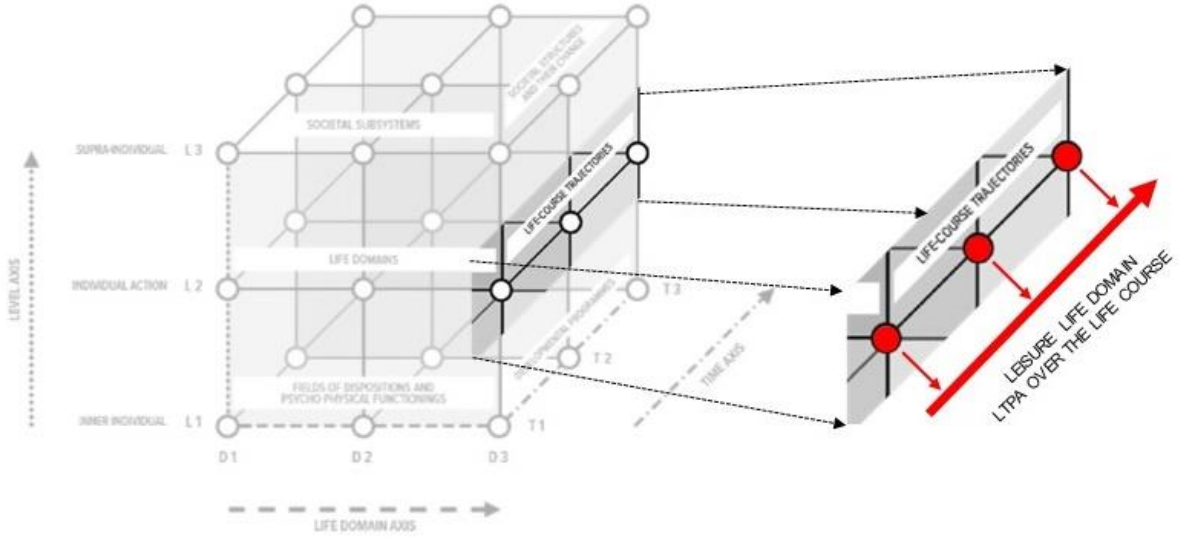

Figure 2. Aspects investigated in manuscript 1 from the *Life Course Cube* (Bernardi et al., 2019; figure adapted from Bernardi et al., 2019, p. 4, https://www.sciencedirect.com/science/article/pii/S1040260818301850#fig0005, CC BY 4.0 https://creativecommons.org/licenses/by/4.0/).

5.2 Manuscript 2

> Lenze, L., Klostermann, C., Schmid, J., Lamprecht, M., & Nagel, S. (2023). The role of leisure-time physical activity patterns in youth for lifelong activity – a latent profile analysis with retrospective life course data. *German Journal of Exercise and Sport Research.* https://doi.org/10.1007/s12662-023-00884-9

Similar to manuscript 1, time-related dependencies of LTPA behavior over the life course were studied (principle 1); however, in contrast to manuscript 1, youth as a particularly relevant life stage for further health behavior (Sawyer et al., 2012), including LTPA (Kirk, 2005), was the focus, and the relationship with lifelong LTPA was investigated (RQ 2; see Figure 3). Therefore, while viewing LTPA behavior as an interactional process of individual and context aspects (Agans et al., 2013; Zarrett et al., 2009), patterns of time- and context-related factors

regarding LTPA behavior were searched in *n* = 1519 individuals between 25 and 76 years of age. More precisely, four indicators in youth (3 to 20 years of age) were used: (1) number of regularly active years (0-18); (2) number of different activities practiced (0-5); (3) whether self-organized activities (0, 1) and (4) organized activities were practiced (0, 1). With the latent profile analysis (Masyn, 2013), six distinct patterns were identified. Under control of age, the relationship to an index of lifelong LTPA (0-1) was calculated.

Overall, the *mostly inactive youth* are the least active in adulthood (index = 0.47, meaning 47% regularly active years throughout adulthood), whereas several other patterns are associated with high activity levels in adulthood. The *low diversely active, self-organized early starters* (index = 0.85) and the *very diversely active early starters* (index = 0.84) are the most active over adulthood, while the *very diversely active late entrants* (index = 0.82) almost reached this level, followed by the *low diversely active, organized early starters* (index = 0.79). The *low diversely late entrants* (index = 0.76) comprise the second-lowest level regarding lifelong LTPA (for significant differences between profiles, see manuscript 2 in Appendix B).

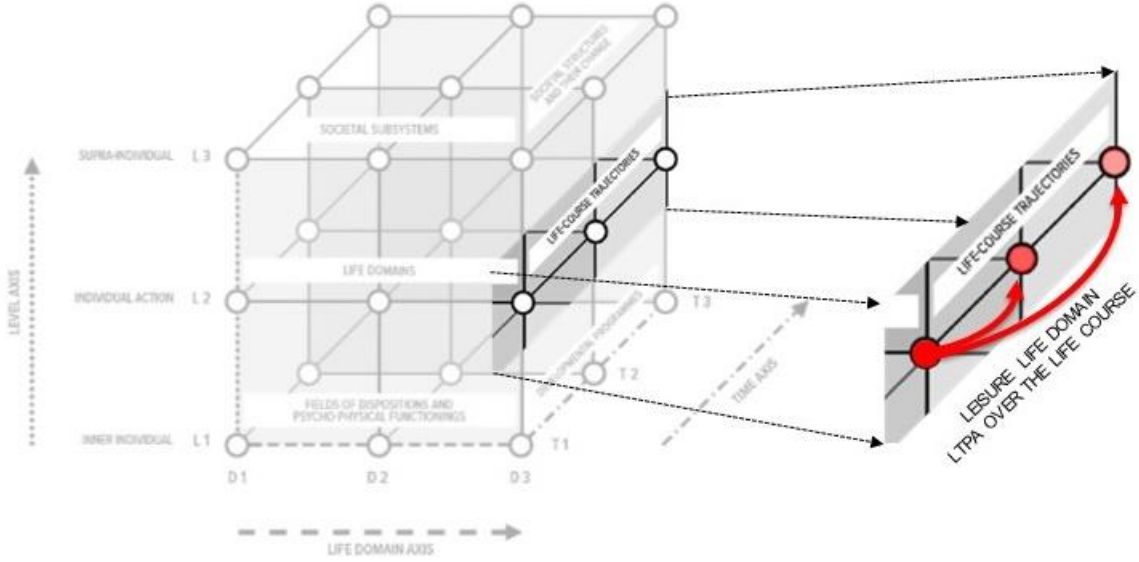

Figure 3. Aspects investigated in manuscript 2 from the *Life Course Cube* (Bernardi et al., 2019; figure adapted from Bernardi et al., 2019, p. 4, https://www.sciencedirect.com/science/article/pii/S1040260818301850#fig0005, CC BY 4.0 https://creativecommons.org/licenses/by/4.0/).

Generally, being physically active in youth is better than being inactive. Regarding specific aspects of LTPA behavior in youth, in addition to high values in each indicator (*very diversely active early starters*), at least two indicators must show high expressions to stay physically very active throughout adulthood (*low diversely active, self-organized early starters*, *very diversely active late entrants*, *low diversely active, organized early starters*); however, it only marginally matters, which of these indicators reveal high expressions. Consequently, it seems that there are various ways of being active in youth that allow for achieving a high activity index over the course of life.

In sum, in this study, time-related dependencies over the life course are shown by differentiating LTPA behavior in youth with patterns and their relationships with lifelong LTPA (principle 1).

Therefore, manuscript 2 demonstrates that adding a more specific theory from developmental science (Agans et al., 2013; Lerner, 2006) to the general life course approach while including principle 1 enriches the understanding and explanation of individual behavior over the life course.

5.3 Manuscript 3

Lenze, L., Klostermann, C., Lamprecht, M., & Nagel, S. (2021). Taking up and terminating leisure-time physical activity over the life course: The role of life events in the familial and occupational life domains. *International Journal of Environmental Research and Public Health, 18*, 9809.

In comparison to the first two studies with the focus on the leisure life domain, the perspective here is broadened by including other life domains to describe and explain LTPA behavior (see Figure 4). Thus, the authoritative principle 2 of this thesis is under investigation. In extension to manuscript 1, which examines terminating and taking up LTPA over the life course explained by factors within the leisure life domain, an attempt was made here to understand and explain transitions in LTPA with the inclusion of other life domains by considering life events from the familial and occupational life domains (spillover effect). Moreover, the timing of events (principle 3) was integrated taking age-related differences into account. Furthermore, derived from the theory of individual resources (see chapter 2.2.2.2), in addition to single life events, multiple life events experienced simultaneously were included (see RQ 3).

Therefore, a person-year file (N = 29,238) of n = 1857 participants aged from 16 to 76 years was created with data representing the years 2004-2019. Multi-level discrete-time event-history analyses (Steele, 2011) were used to model the relationship between life events and taking up or terminating LTPA over this period.

Regarding single life events from the familial life domain, starting a relationship was associated neither with taking up nor with terminating LTPA over the life course. Ending a relationship was linked to a higher probability of taking up LTPA over the life course and to a greater chance of terminating LTPA only in men. When becoming a parent, taking up LTPA was overall less likely, while terminating LTPA was more likely for women with an increasing effect with age. For the occupational life domain, starting vocational training was not related to taking up LTPA but to terminating LTPA with a higher probability when individuals were between 30 and 44 years of age. Starting a job had no relationship with transitions in LTPA, whereas ending a job was only associated with a higher probability to terminate LTPA over the life course. Retirement was linked to a higher chance of taking up LTPA. The more life events experienced simultaneously overall, the more likely taking up LTPA between 45 and 70 years of age, and conversely, there was a higher probability of terminating LTPA for those aged 15-44 years.

Consequently, life events can support and hinder LTPA behavior. The timing of when an event occurs in the life course can be decisive regarding transitions in LTPA, meaning that the effect

depends on age or the life stage. Furthermore, it seems that a larger redistribution of individual resources occurs the more life events are experienced simultaneously. Of note, the timing respective of the life stage is crucial: in younger years (15-44), the resources are apparently shifted away from LTPA, whereas in older years (45-70), the different life changes provide an opportunity to take up LTPA.

In conclusion, spillover effects (principle 2) and the relevance of the timing of events (principle 3) were observed. Thus, LTPA behavior over the life course is associated with other life domains and depends on the timing of events respective of age. With a more specific theory in addition to the general life course research, individual resources provide an explanation approach to how and when life events are related with transitions of LTPA behavior over the life course, even if the resources are not represented in our data.

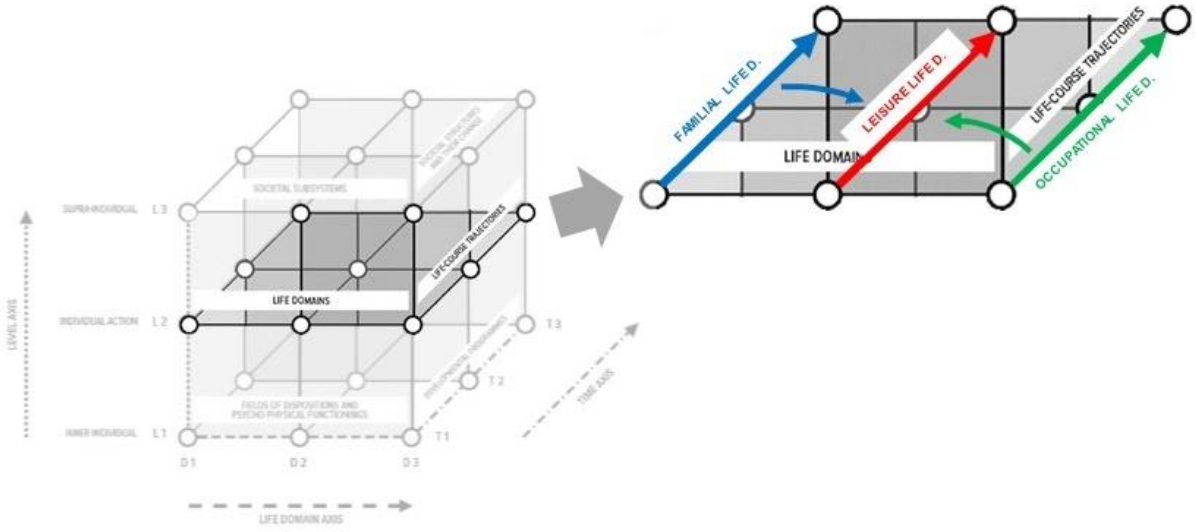

Figure 4. Aspects investigated in manuscript 3 from the *Life Course Cube* (Bernardi et al., 2019; figure adapted from Bernardi et al., 2019, p. 4, https://www.sciencedirect.com/science/article/pii/S1040260818301850#fig0005, CC BY 4.0 https://creativecommons.org/licenses/by/4.0/).

6 Discussion

Individual LTPA behavior over the life course with its factors and events from the leisure life domain and related life domains were investigated in this dissertation. The theoretical orientation builds the life course research, where three central principles are applied (Mayer, 2009; Elder et al., 2003) and adapted to the recent theoretical basis called the *Life Course Cube* (Bernardi et al., 2019). Nearly 2000 Swiss inhabitants aged between 16 and 76 years were interviewed with a validated, retrospective, and quantitative questionnaire. To collect reliable and valid data, efforts at different levels were made, including a validation study (test-retest reliability check), and advanced statistical methods helped to analyze the data related to the theoretical and methodological demands. As a brief summary of the results and to give a short answer to the general research question (see chapter 1), it can be stated that separate aspects (e.g., organizational form, entry age, etc.) of LTPA behavior in different life stages can only explain differences between always-actives and unstable actives over the life course to some extent (manuscript 1), while patterns of LTPA behavior in youth are related to lifelong LTPA (manuscript 2). Moreover, taking up and terminating LTPA over the life course is associated with life events from other life domains, depending partly on the timing of when events occur and whether one or multiple life events are experienced simultaneously (manuscript 3). A deeper discussion of the results and the thesis is provided in the next chapters while differentiating between an empirical (chapter 6.2), theoretical (chapter 6.3), and methodological analysis (chapter 6.4) of this dissertation, and some implications are derived with caution (chapter 6.5); however, first, the embedding of the thesis in the broader scholarly context is discussed.

6.1 Integration of this thesis in the scientific discourse

The project in which this thesis is embedded stems from sport science. Because sport science is often closely linked to "mother disciplines," such as sociology or psychology (cf. Willimzcik, 2011), the project and this thesis can be subdivided into sport sociology. Focusing on the individual LTPA behavior in its environment and context in this thesis, the micro rather than the macro level is addressed in terms of sociology (cf. Esser, 1993). How far or close the micro level of sociology is from psychology depends on the sociological stream (see Willimczik, 2011, pp. 175-179, for a discussion in a sport science setting). The intertwining of sociology and psychology for this thesis also becomes evident when examining the origins of life course research with life course sociology and life span psychology (see chapter 2.1). As reported in chapter 2.1, an integrative approach for investigating life courses was required from both disciplines and evolved even more in recent decades. In conclusion, this thesis has an integrative life course approach influenced by its roots from the life course sociology to describe and explain an object of investigation in sport science – LTPA behavior – over the life course.

Another starting point is studies from a health science perspective, including public health and behavioral epidemiology, which focus mainly on predictors and determinants of physical activity (Fuchs, 1997) and call their concepts "frameworks" (cf. Biddle, Mutrie, Gorely, &

Faulkner, 2021). This empirically driven approach investigates the predictors and determinants of physical activity and the subdimensions thereof (including LTPA), partly by considering other health-related variables also over the life course (Corder et al., 2009). Consequently, such studies enrich the sport science field of research on LTPA as well.

To bridge these two perspectives, from a sport science approach (including sport sociology and life course analyses within it[3]), such research activities and graduation programs include a focus on health (cf. in Switzerland Carrard, Gut, Croci et al., 2022), and from a health science approach, LTPA and sport – also from a narrow understanding – are viewed as contributors to health (e.g., Khan et al., 2012). In summary, a rapprochement can be stated, but we must keep in mind that they will always stem from two different research streams. Consequently, this dissertation is a sport science thesis focusing on the integrative life course approach with its roots in sociology and with a relevance to health science by investigating LTPA as a health-relevant aspect.

6.2 Empirical contributions

Based on the general research gap of a lack of longitudinal studies that investigate the interdependencies of LTPA aspects over the life course (see chapter 1), this thesis extends the state of research as follows.

By viewing LTPA behavior over the life course as activity-inactivity episodes, correlates of the distinction between different groups (*always active early starters*, *always active late starters*, *unstable LTPA*, *never active*) were rarely found in socioeconomic aspects, while a high number of self-organized activities in youth and young adulthood was the only factor within the leisure life domain that clearly differentiated the *always-active early starters* from the others (RQ 1). Thus, whereas socioeconomic aspects are not strongly related to lifelong LTPA without any transitions compared to LTPA trajectories with transitions, being self-organized active in younger years helps to stay lifelong active, which is a new result in this field of research.

Identifying patterns of LTPA behavior in youth to determine whether there is an association with lifelong LTPA has not yet been done. For manuscript 2 of this thesis, various qualitative distinct patterns emerged and reflected different "activity types" of LTPA behavior in youth. Furthermore, there is more than one pattern from youth related to a high index of lifelong LTPA, indicating multiple ways of staying physically active throughout adulthood (RQ 2). Related to RQ 1, a self-organized setting in youth seems beneficial for lifelong LTPA, which appears to be a trendy organizational form with a higher demand in adulthood (Eime et al., 2020; Eime et al., 2015). The other favorable patterns are mainly characterized by diverse LTPA engagement in youth. In addition to existing studies on the predictors of LTPA in youth for later activity

[3]Life course research can also be seen as a stand-alone perspective or even discipline; however, in this thesis, life course research is viewed as a theoretical and methodological aid to investigate LTPA behavior and sport behavior over the life course in an overarching sport science field (similar to Conzelmann, 2001; Nagel, 2002; Klostermann, 2012).

(see chapter 2.2.1.2), this approach used with patterns offers a new perspective of time-related dependencies over the life course.

By broadening the focus to relevant aspects of LTPA behavior over the life course outside of LTPA itself, life events from other life domains are well-known influencing factors on LTPA behavior. In addition to the existing research on separate life events and their relationships with LTPA behavior for the respective life stages (see chapter 2.2.2.1), this study expanded this view and showed different effects depending on the life stage and the number of life events experienced simultaneously (RQ 3). Considering the life stage and multiple life events simultaneously – especially in the same study - has not yet been done and indicates age-depending effects as well as the importance of not only focusing on the occurrence of separate life events when investigating their relationships with LTPA behavior.

6.2.1 Strengths

As reported, some empirical research gaps could be complemented by this thesis. In addition, and generally speaking, this is the first investigation on LTPA behavior over the life course in Switzerland. Thus, this thesis offers insights into people's LTPA behavior in this societal, cultural, and political setting, which can be helpful to derive practical implications within this environment. Furthermore, the data in this dissertation represent precise and differentiated aspects of LTPA behavior and were not taken from a panel data set. This allows for targeted research questions and examinations for this field of research. Consequently, in-depth investigations of LTPA behavior over the life course were possible, such as for detailed aspects of LTPA behavior per life stage (e.g., organizational settings, type of activity, etc.) or the combination of multiple life events related to transitions in LTPA at different time points in life.

6.2.2 Limitations and future research

First, considering life course research is a highly complex and interwoven research area, not all influencing aspects can be investigated at once (cf. Bernardi et al., 2019). Thus, the aim of the three main research questions (RQ 1-3) was to cover a large part of the phenomenon under investigation, but they might be combined to understand LTPA behavior over the life course more in-depth (e.g., are younger individuals less prone terminating LTPA by experiencing multiple life events when they were self-organized active?). Furthermore, including both the supra-individual and inner individual levels in addition to the individual action level of the *Life Course Cube* (see Figure 1) may help to better understand the interdependencies of LTPA behavior over the life course. The individual action level in combination with the inner individual level is studied in the *Cardiovascular Risk in Young Finns Study* (e.g., Juonala, Viikari, & Raitakari, 2013), whereas the individual action level and the supra-individual level were investigated in Germany (Klostermann & Nagel, 2014; Breuer & Wicker, 2009). One approach to obtaining deeper insights into these interdependent mechanisms is performing

qualitative studies with no statistical restrictions in this complex interplay of factors (see also Li et al., 2009). Second, the results of the thesis show dependencies in the life course but are restricted to this sample of Swiss inhabitants, who do not reflect a representative sample and who tend to be a physically above-average active sample. Third, LTPA is viewed as a health-promoting behavior (see chapter 1) and was operationalized as at least once per week; however, further relevant information regarding health benefits - i.e. the intensity and frequency (except at least once a week) - was not collected over the life course. Thus, no clear statement can be made regarding whether the WHO recommendations for physical activity are fulfilled or not, nonetheless a regularity of once per week already induces positive effects on health (e.g., Arem et al., 2015; de Boer, 2022; Hamer et al., 2009; Sattelmair et al., 2011).

Overall, studies that can provide as holistic a picture as possible of LTPA over the life course are still needed, with a qualitative design too. The replication and generalization of these results with other samples, including representative ones, would enrich the understanding of this topic. Moreover, particularly inactive groups of individuals (e.g., low-income or immigrated people; Lamprecht et al., 2020) could be studied in a targeted and more detailed manner throughout the life course to explain their behaviors and to derive strategies for this relevant group regarding health promotion. The future investigations proposed should include the recording of the frequency and intensity of LTPA behavior over the life course as well as other health aspects (e.g., psychological well-being, cardiovascular diseases, etc.) to obtain deeper insights into the possible health effects.

6.3 Theoretical contributions

In this thesis, no new theory was developed; rather, certain theoretical approaches were newly combined, and existing theoretical principles can be derived and supported in this field of research.

For this life course research study, three basic principles from life course sociology (Elder et al., 2003; Mayer, 2009) were applied (see Table 1). They can be adopted to the more integrative understanding of life course research, the *Life Course Cube* (Bernardi et al., 2019), and are supported with our results: time-related dependencies are also evident in the field of LTPA over the life course (principle 1), life domains are interdependent, other life domains help to understand and explain LTPA behavior in the leisure life domain (principle 2), and depending on the timing of events, different consequences regarding LTPA behavior evolve (principle 3). Hence, these general principles are valid for the investigated topic.

Furthermore, this thesis shows that an integrative approach using sociologically but also psychologically driven theories can be fruitful: in addition to the general, integrative understanding of combining these two disciplines to analyze life courses (e.g., Conzelmann, 2001), in manuscript 2, the interplay of individual factors (more psychologically driven) in the social and physical environment (more sociologically driven) over time is shown, which helps to understand and explain the relationship between LTPA behavior in youth and lifelong LTPA. Thus, the developmental science stemming from a mainly psychological background (Cairns et

al., 1996; Lerner, 2006; Overton, 2015) and the life course research from a sociological background (Bernardi et al., 2019) often use different terms to describe the same phenomenon (example: whereas Bernardi and colleagues (2019) speak about time-domain-level interdependencies to understand life courses, Lerner (2021, p. 1) describes "Development as Individual ←→ Context Relations Across Time and Place").

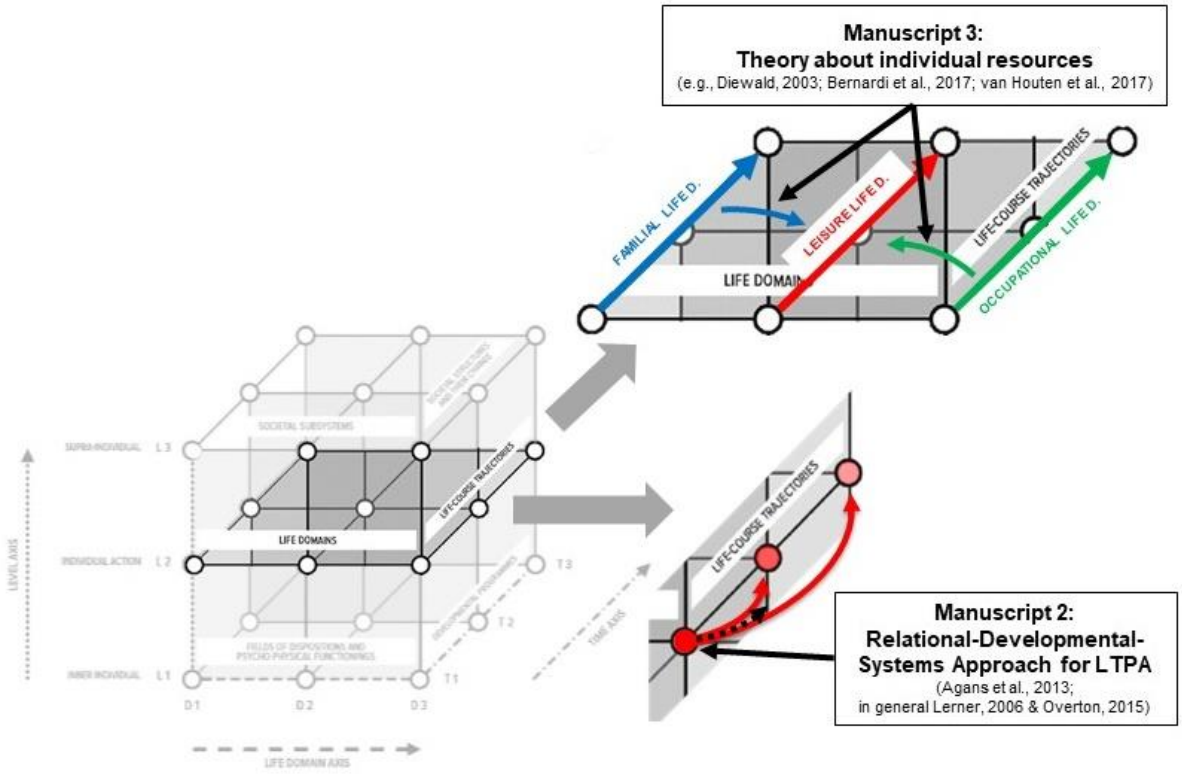

Figure 5. Complemented specific theories used embedded in the *Life Course Cube* (Bernardi et al., 2019; figure adapted from Bernardi et al., 2019, p. 4, https://www.sciencedirect.com/science/article/pii/S1040260818301850#fig0005, CC BY 4.0 https://creativecommons.org/licenses/by/4.0/).

The theoretical foundation of this thesis, the *Life Course Cube* (Bernardi et al., 2019), helps to systematize the different studies of this thesis (see Figure 2-4). Due to the non-specific character of this theoretical foundation (or in Overton's (2015) understanding "metatheory"), complementary theories are enriching (Bernardi et al., 2019). Therefore, in manuscript 2, a more specific theory is used by adapting the *Relational-Developmental-Systems Approach* (Lerner, 2006; Overton, 2015) from developmental science to LTPA (Agans et al., 2013), and it supports the precise description of the object of investigation. In a similar manner, in addition to the *Life Course Cube*, the theory regarding individual resources is complemented by manuscript 3 (e.g., Diewald, 2003; see chapter 2.2.2.2), which was already adapted to LTPA (van Houten et al., 2017) to provide an explanatory approach for the relationship between life events and transitions in LTPA. In conclusion, to describe and explain LTPA behavior over the life course, the general *Life Course Cube* (Bernardi et al., 2019) served as the theoretical starting point, and depending on the research questions, more concrete theories were applied if an added value regarding the precise description of the object of investigation was given (see Figure 5).

This is exemplary of the enrichment to better understand the phenomenon when using the general life course approach and additional theories.

6.3.1 Strengths

In this thesis, principles of life course sociology were adapted to the recent understanding of life course research, the *Life Course Cube* (see Table 1). With this integrative understanding, the real-world phenomenon, LTPA behavior over the life course, could be investigated without disciplinary boundaries. Hence, additional theories originating from both psychological and sociological backgrounds could be integrated into the general theoretical approach (see Figure 5), and the respective manuscripts could be classified into the general theoretical approach as well (see Figure 2-4). Thus, the relations between the different manuscripts and additional theories are visible, and comparisons can be made. This integration and classification in one overarching theoretical approach helped to provide as holistic a picture as possible to represent the complex LTPA behavior over the life course adequately in a theoretical manner.

6.3.2 Limitations and future research

The non-specificity of the theoretical basis also provides disadvantages. The authoritative principles of this thesis are formulated very generally. Thus, it is difficult to formulate or to derive concrete assumptions or hypotheses. Consequently, a more specific theory would be desirable from this perspective, though it may not be possible due to the complexity of the phenomenon (by using additional theories, there was an attempt to overcome this issue).

Regarding the *Life Course Cube* (Bernardi et al., 2019), this thesis focuses on the individual level over the life course in the leisure life domain and related life domains; however, for example, principle 3 (timing of events) of this thesis also depends on social regulations und age-graded norms (Elder, 1995; see chapter 2.2.2.1), which can be categorized at the supra-individual level. Therefore, not only was the individual level included in describing and explaining LTPA behavior over the life course, but little “detours” to the supra-individual level were also applied. Possibly due to the intertwining of the individual behavior of the life course across different levels, this separation is theoretically not always possible. Thus, theories for a specific LTPA behavior over the life course across levels, or in other words, the *Life Course Cube* adapted and more specified for LTPA, would be beneficial (e.g., Klostermann, 2012, already included the individual and supra-individual levels).

The currently available theoretical approaches contribute to creating a structure and classification to describe and partly explain LTPA behavior over the life course. Regarding the causes or underlying mechanisms for changes or predictions of LTPA behavior over the life course, there is only sparse research. For example, the following question has not yet been answered: to what extent are which individual resources relevant to staying physically active? Therefore, existing theories from other areas could be combined to explain the phenomenon of LTPA behavior over the life course (for the aforementioned question raised, e.g., time-

allocation model from Becker, 1965; or social capital theory from Lin, Cook, & Burt, 2001), or new theories should be developed. Another example would be the time-related dependencies of LTPA behavior over the life course. As reported, Telama (2009) formulated hypotheses to explain this relationship (see chapter 2.2.1.2); however, there are no empirical investigations that prove these hypotheses (to the best of the author's knowledge). Our data show that, for example, starting with self-organized activities in early years seems promising for lifelong activity, but why this is the case we can only speculate and formulate assumptions. In sum, answers of such "why" questions would help to better understand and explain the phenomenon. Formulating hypotheses, testing them, and building theories thereof lead to more precise research and thus to deriving more concrete implications about the object of investigation. In conclusion, theories that explain the causes or underlying mechanisms of the interdependencies of LTPA behavior over the life course are an object of future research.

6.4 Methodological contributions

The whole thesis is based on one data set. Thus, the issues of collecting retrospective data (see chapter 4.2), and the assistance and participation in the further development and validation of the questionnaire and data collection, methodological learnings, and pitfalls are reported in the following.

For the reliability check with the test-retest method (see Table 2), the methodological approach to data collection seemed to yield mainly reliable data (except frequency, which is discussed in chapter 6.4.2 below). Consequently, gathering this kind of reliable information, meaning objective, past experiences in one's own LTPA life course, appears feasible with this approach. Thus, data regarding various LTPAs practiced, the organizational setting and the timing, and when someone was regularly active or not seem to be well-stored, retrieved, and therefore remembered. The recording of life events from different life domains in the last 15 years reveals a very high reliability, indicating that life events are personally relevant enough to be precisely remembered. In summary, the methodological approach chosen with the CATI-method and other efforts, including autobiographical assistance, qualitative and quantitative pretests, and interviewer training, provide a way to collect reliable data on a differentiating level, as for this study. Furthermore, to analyze the data, demanding statistical methods, such as multi-level and latent models, were calculated using three different programs (SPSS, R, Mplus) to meet the empirical (e.g., modeling multiple episodes of life events and transitions in LTPA per individual), theoretical (e.g., represent LTPA behavior as individual-context-relations), and methodological (e.g., violation of the assumption of uncorrelated residuals for multiple measurements per individual) requirements (cf. Li et al., 2009).

6.4.1 Strengths

By using the aforementioned methodological approach, a (cost-)efficient possibility was found to collect reliable, longitudinal data. As mentioned in chapter 6.2.1, the data are "at first hand"

and specifically recorded for the project in which this thesis is embedded. In addition, the sample of nearly 2000 Swiss inhabitants allowed for statistical analyses with high demands regarding the sample size, and therefore an appropriate analysis method could be used. Consequently, the accurate and differentiated data regarding LTPA behavior over the life course from a large sample were well-processed and calculated due to the sophisticated analyses methods used (see chapter 6.4 above). Moreover, the participants ranged from 16 to 76 years of age at the time of the survey. In comparison to a prospective study with one age cohort, effects based on one age cohort can be ruled out with this data set.

6.4.2 Limitations and future research

As discussed in chapter 4.2, retrospective data are not free from recall problems. From the reliability test, it can be concluded that mainly reliable data were collected, but no statement can be made about validity. The validity of self-reported physical activity data can vary (Dowd et al., 2018), which could be due to an overestimation of one's physical activity behavior (Ainsworth & Levy, 2004). Regarding the reliability test more in detail, it is evident that the frequency of LTPA, the days and hours per week, shows a low reliability for all life stages. Thereby, it is unclear whether this caused by the problem of recall or by the question per se. Thus, no detailed information for the frequency per week of past LTPA can be deduced. Related to this, in addition to the efforts mentioned to collect as reliable data as possible, one promising approach, the event-history calendar (e.g., Drasch & Matthes, 2013), was not integrated into the data collection process for technical reasons.

In sum, in addition to the mainly reliable data collected for this thesis, recording longitudinal data assessing LTPA behavior with a proven, high validity is desirable. This might be achieved with the implementation of an event-history calendar or other methods so that a reliable statement about the frequency of past LTPA behavior can be made. In addition to the advanced statistical methods used, there are already more sophisticated methods that could potentially represent the interdependencies over the life course even more holistically (e.g., sequence analyses; Piccarreta & Studer, 2019).

6.5 Practical implications

Before drawing practical implications, the general limitations of this thesis, such as the not-representative sample and the country-specific characteristics (e.g., sport system, culture, etc.) where the data were collected, must be kept in mind.

Results from observational studies such as this one can lead to recommendations for interventional studies or practical interventions, particularly for the timing of interventions in the case of life course studies (Li et al., 2009). Thus, this thesis indicates that youth appears to be an important life stage to shape positive LTPA behavior over the life course; however, it has become evident that there is not one way or type of activity that is beneficial regarding lifelong LTPA. Rather, a diverse participation profile and/or an early entry into LTPA in youth helps to

stay physically active, and self-organized activities are a particularly promising setting for this. Consequently, promoting diverse aspects of LTPA and providing opportunities (e.g., infrastructure, easier access, etc.) to be diversely active, including self-organized activities, in youth should be considered by policy makers.

Many dropouts or declines in physical activity occur at the end of youth or in young adulthood in general (e.g., Corder et al., 2019), an effect that is at least supported by experiencing multiple life events simultaneously. Therefore, strategies to prevent this negative development or novel offerings that are compatible to new life situations should be developed. During the entire life course, life events should not only be seen as a risk but also as an opportunity to use the new life situation to start (additional or other) LTPAs. In addition to the well-known window of opportunity for LTPA when retiring (e.g., Barnett et al., 2012), experiencing multiple life events in middle and late adulthood can also be seen as an opportunity to enter or intensify LTPA. Hence, diverse and targeted offerings for different life situations for this age group should be considered.

6.6 Conclusion

This dissertation examines different aspects of LTPA behavior over the life course by using retrospective and validated life course data from nearly 2000 Swiss inhabitants. Considering an integrative life course approach (Bernardi et al., 2019), various dependencies over the life course become evident: time-related dependencies, especially between LTPA in youth throughout adulthood, and dependencies between life events of other life domains and transitions in LTPA behavior over the life course. Thus, the intertwining of various aspects over the life course can also be shown for LTPA behavior. By integrating additional theories to describe and explain the dependencies more in detail, the thesis contributes to the integrative field of sport science dealing with the study of LTPA behavior and has implications for health science and life course research. These new insights gained help not only to derive implications for future research activities but also to (further) support health-promoting strategies, such as Youth+Sport and offerings that combine multiple life domains (e.g., exercise opportunities at work; see chapter 1).

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Appendix

Appendix A: Manuscript 1

Sport and leisure-time physical activity over the life course

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ABSTRACT

It is desirable to get as many people as possible to engage in long-term leisure-time physical activity (LTPA) due to the health-enhancing effects. Although the proportion of individuals who are physically active in their leisure time appears to have increased in Switzerland in the past years (e.g., Lamprecht et al., 2020), little is known so far about the dynamic of change in LTPA trajectories over the life course. LTPA trajectories of 1,456 Swiss residents aged 35 to 76 years (random sampling) were reconstructed with the help of a retrospective telephone interview (CATI method). To address the difficulties of retrospective data collection, the article presents the careful development of the questionnaire on the basis of current evidence. The majority of the respondents (approx. 73%) show a long-term LTPA without dropout (dropout = LTPA less than once a week over one year and longer), only a minority of whom (approx. 18%) took up their LTPA after the age of 20. In addition, there is also a group with a somewhat unstable LTPA trajectory (approx. 24%) that includes at least one dropout. For members of the latter group, the longer the inactive episode lasted, the lower were their chances of entering an LTPA. While the different LTPA trajectory groups differed only slightly with regard to socioeconomic characteristics, analyses of their sport- and physical activity-related history reveal that self-organized LTPA in childhood and youth may be seen as a success factor for lifelong LTPA. The proportion of people practicing (long-term) LTPA is presumably overrepresented in the sample. This limitation should be taken into account, but analyses of possible advantageous conditions of long-term or lifelong LTPA are nevertheless possible. The results indicate a demand for more specific theories related to the causality behind the observable LTPA behavior.

Keywords

leisure-time physical activity (LTPA), stability, life course, retrospective longitudinal study, Switzerland

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Introduction

Many societal protagonists aim to provide as many people as possible access to a lifestyle of physical activity and sport throughout their lives due to the health-enhancing effects of physical as well as sport activity. So far, however, this has not been achieved to a satisfactory degree. Physical inactivity costs Switzerland around two billion Swiss francs per year in direct treatment costs (Bundesamt für Sport et al., 2013). These costs could be lowered if a larger part of the population maintained an active lifestyle and participated regularly in sport activities. The achievement of health-enhancing effects requires avoidance of inactive behavior (e.g., sitting for too long) and maintenance of regular engagement in sport and physical activity over a long period, if possible for one's entire life (Bundesamt für Sport et al., 2013; Rütten & Pfeifer, 2016). Around 35 percent of adults in Switzerland do not meet the national recommendations for health-enhancing physical activity (Bundesamt für Sport et al., 2013). A closer look also reveals that particular social groups (such as the elderly, persons with a low level of education or a migration background) have found access to health-enhancing physical activity less often up to now (Jekauc et al., 2018; Lamprecht et al., 2020). However, time-series studies have shown that the proportion of physically active persons in Switzerland has increased in the past decades (Bundesamt für Sport et al., 2013; Storni et al., 2019). Although such repeatedly conducted cross-sectional studies can show a certain trend, they cannot portray the maintenance of physical activity or the dynamic of changes in terms of entering and exiting health-enhancing sport and physical activities. In this context, it seems significant for the promotion of physical activity and sport to obtain more knowledge on trajectory and maintenance in order to achieve the goal of long-term or lifelong health-enhancing sport and physical activity. The trajectories of persons who participate in sports and physical activity on a long-term basis are of particular interest for finding out more about the conditions for the success of long-term and lifelong sport and physical activity. Altogether, the stability of LTPA over the life course appears to be "low to moderate" (Aggio et al., 2017; Beunen et al., 2004; Borgers et al., 2018; Engel & Nagel, 2011; Hirvensalo & Lintunen, 2011; Jekauc et al., 2018; Klostermann & Nagel, 2011; Kristensen et al., 2008; Malina, 2001; Telama, 2009; Trudeau et al., 2004). To date, little evidence is available on the issue of which factors influence the trajectory of health-enhancing physical activity. Initial findings indicate that significant determinants include socioeconomic factors (e.g., LTPA is less stable in younger women and in persons with a lower level of education; see Hirvensalo & Lintunen, 2011; Lamprecht et al., 2020) as well as the particular sport and its organizational setting (e.g., Kjønniksen et al., 2009; Klostermann & Nagel, 2011; Telama, 2009). In summary, a review of the current state of research shows that there are relatively few longitudinal studies on health-enhancing physical activity that measure it over the entire lifespan. Related considerations of

the life-course trajectory of sport and physical activity as a process of change, investigation of possible connections, and advantageous conditions have not yet been taken into account.

This article builds on these findings and research gaps by focusing on LTPA over the entire life course as an element of health-enhancing physical activity (HEPA).[1] The central questions addressed are how LTPA develops over the life course and what stability it exhibits, as well as to what extent the life-course trajectories of LTPA differ across various groups of individuals. Taking the theoretical and methodological approach of life course research developed by Mayer (1990, 2009) as a starting point, we analyzed the trajectories of LTPA over the life course of individuals in middle and later adulthood in a retrospective longitudinal study.

Theoretical Framework

The sociological life course approach developed by Mayer (1990, 2009) and the "life course cube" published by Bernardi et al. (2019) provide a suitable theoretical and methodological framework for our question of interest. Accordingly, LTPA is conceptualized at the individual action level as a sequence of activities (e.g., participation in sport activities) and events (e.g., entering or exiting the sport activity) over the life course, which include exercise, sport, and unstructured recreation practiced at least once a week. In other words, the trajectory of LTPA over the life course is characterized by alternating episodes of activity and inactivity (LTPI), the maintenance of which may be influenced by various factors (see also Allmer, 2002). To date, only very few studies have investigated LTPA empirically over the life course as alternating episodes of activity and inactivity (Engel & Nagel, 2011; Jekauc et al., 2018). In view of the central questions of the present study, various temporal dependencies of LTPA over the life course are of particular interest. The "life course cube" by Bernardi et al. (2019) illustrates the complexity of time-related interdependencies over the life course. For example, individual behavior and decisions are affected by social (normative) expectations, such as typical development tasks at different stages of life (e.g., becoming a parent, entering retirement). As Mayer (1990, pp. 11, translated) states, "events, phases, transitions, and stages of life cannot be considered in isolation or situationally. […] Lifetime in particular is a constraint for actions". According to the notion of path dependency, current individual actions and decisions (e.g., entering or exiting a sporting activity) are influenced by previous experiences, and they also constitute the starting point for future individual actions and decisions (Bernardi et al., 2019). What is considered relevant in this connection is the duration of the episodes (e.g., duration of LTPA or LTPI in years). The longer the episodes last, the lower is the probability of an entry or exit (e.g., Engel & Nagel, 2011). The history of sport participation and LTPA over the life course and in its entirety (e.g., experiences in various sport activities in different sport organizations with and without competition participation) seems to be of greater importance than individual autobiographical "states" at individual points in the life course (Bernardi et al., 2019). In other words, it is believed that just the state of being physically active in one specific year will have less influence on the future trajectory of sport and physical activity than the entire experiences over a longer period of time. However, the current state of research cannot answer the question of which periods are crucial and what the difference is between long-term stable LTPA trajectories and less stable LTPA tra-

1. Health-enhancing physical activities (HEPA) are understood as all physical activities that lead to an increase in energy metabolism through the use of the skeletal muscles, thereby promoting health and functional capacities (e.g., Foster, 2000). They include both occupational physical activities (OPA) and leisure-time physical activities (LTPA). This study is focused on LTPA and the used definition refers to Khan et al. (2012), who distinguish four types of physical activity: occupational; transport; domestic; and leisure time, which includes exercise, sport, and unstructured recreation. Accordingly, e.g., regularly going for a walk or riding a bicycle during leisure time (and not as a transport activity for the purpose of going to work) counts as LTPA in this study if it is practiced at least once a week, but not gardening as a domestic physical activity.

jectories? Initial research findings indicate that it is advantageous for the stability of sporting activity to engage in several sports and physical activities which can be maintained over the entire life course, such as swimming and cycling, or to participate in them in a club (e.g., Kjønniksen et al., 2009; Klostermann & Nagel, 2011; Lunn, 2010; Tammelin et al., 2003; Telama, 2009). In addition, the question of particularly relevant and sensitive periods for lifelong sport and physical activity is not yet settled. The stage of childhood and youth is traditionally attributed special importance, in the sense that this is the stage at which the foundation for long-term or even lifelong sport and physical activity is laid (e.g., Batista et al., 2019). However, several empirical studies indicate that it is also possible to take up regular sport and physical activity in adulthood and that this can also lead to long-term activity (e.g., Frändin et al., 1995; Hirvensalo & Lintunen, 2011; Klostermann & Nagel, 2011).

In summary, these theoretical considerations lead to the question of what kinds of temporal dependencies should be regarded as relevant for LTPA over the life course. The following research questions can be specified:

Q1: To what extent can LTPA over the life course be described as a sequence of activity and inactivity?

Q2: To what extent does the duration of episodes of LTPA or leisure-time physical inactivity (LTPI) influence the probability of an entry or exit?

Q3: What characteristics of sport and physical activity-related history (e.g., type of sport and physical activities, organizational setting, competition participation) do persons who are physically active in their leisure time on a long-term to lifelong basis exhibit?

Q4: What role do socioeconomic factors (e.g., level of education) play with regard to the life-course trajectory of LTPA?

Method

The theoretical considerations and assumptions lead in the next step to several methodological consequences. The theoretical demand for the most precise possible measurement of sport and physical activity-related history raises the question of how to measure LTPA over the life course in a sufficiently differentiated manner. On the whole, the life-course trajectories of LTPA should be portrayed over relatively long periods. Retrospective interviews are suitable for this purpose, not only for reasons of research pragmatism but also in the interest of avoiding systematic sample bias and recall bias. However, such interviews in turn place great demands on the autobiographical memory of the respondents. Various methods and procedures for enhancing recall in retrospective data collection have been developed and evaluated in recent years (Glasner & Van der Vaart, 2009; Matthes et al., 2007; Morselli et al., 2018). We endeavored to implement them in this study through the further development of an existing questionnaire for telephone interviews (CATI method) on the retrospective measurement of LTPA over the life course (e.g., Klostermann & Nagel, 2011). In view of the temporal dependencies of LTPA over the life course, an empirical analysis requires at least year-specific dating of the activities and events so that the respective durations can be determined. In addition, the life-course trajectory of LTPA should be defined in as broad terms as possible through the inclusion of different forms of participation (e.g., organizational setting, physical or sport activity, competition participation, age of entry).

Instruments

We structured the questionnaire in accordance with the idea of thematic recall pathways (Matthes et al., 2007), thus beginning in very general terms by covering current sport and physical activity with a dichotomous yes–no question and continuing with a list of all sports and physical activities practiced. Then, increas-

ingly specific questions were asked on frequency, organizational setting, and the date each sport and physical activity was begun (see A for an extract from the questionnaire).

Recall of previous sport and physical activities was supported through the adoption of a sequential approach starting from childhood and youth through younger adulthood to middle adulthood, with questions on particular sport and physical activities at the individual stages again proceeding from the general to the specific. We tried to initiate cross-thematic recall pathways in accordance with Matthes et al. (2007) by including important life events in the areas of family, education, and career, as well as history of living situation before the questions about previous sport and physical activities (e.g., Lenze et al., 2021). Overall, the combined sequential and modular approach in the interviews provided targeted support for the recall work of the respondents (e.g., Matthes et al., 2007).

In addition, we tried to encourage recall by individualizing the interviews in some respects. To be specific, information previously provided by the respondents was automatically transferred to modules appearing later in the interview (e.g., if the respondent's current sport and physical activity started in childhood, this fact was automatically transferred to the questions about this life stage in the interview).

We tested and evaluated the resulting "Sport and Physical Activity over the Life Course" questionnaire in several pre-studies.

Measures

LTPA: For the analyses in this paper, we observed only regular sport and physical activities. The term "regular" refers to at least once a week. The definition of LTPA we applied (Khan et al., 2012) includes all physical activities performed during leisure time, without those performed for occupational, domestic, or transport purposes. We collected data on specific types of LTPA, frequency of participation, organizational setting, and competition participation at the particular life stages.

As suggested by Sudeck et al. (2011), we categorized the statements on the specific sport and physical activities into 10 activity groups (walking and endurance activities, fitness, gymnastics and multi-sport activities, athletics, compositional-creative activities, release-oriented activities, outdoor and mountain activities, sports games, martial arts, equestrian).

To portray the LTPA trajectories over the life course, we used the respondents' statements on entry to and exit from the particular sport and physical activities as well as their statements on interruptions of over one year's duration. Thus, episodes of activity and inactivity were built, with years as the time unit.

We already took some socioeconomic data into account in the sampling process using the data of the Swiss Federal Statistical Office (e.g., sex and age) and verified them at the beginning of the interview. Level of education was included in the survey of vocational and educational life events and was classified for the present analyses into one of two groups, "obligatory school-leaving qualification & vocational training" and "higher education entry qualification & tertiary education". Nationality was included at the end of the interview. All persons who currently had Swiss nationality (Swiss citizens and dual citizens with Swiss nationality) and those who had exclusively foreign nationality were included in the present analyses.

Pre-studies

Pre-study 1, "Cognitive pretest"

The aim of this first pre-study was to evaluate the questionnaire for comprehensibility as well as for possible difficulties in the recall process through the think-aloud protocol, confidence rating, and coding of behavior in responding to the questions (Dürnberger et al., 2011; Moosbrugger & Kelava, 2020). We conducted a total of nine face-to-face interviews (six female and three male respondents; aged 18 to 83 years; M_{age} = 41, SD = 20.57). In the confidence rating, the respondents stated that they were fairly certain of their response (Likert scale from 1 = not certain to 4 = very

certain; *M* = 3.63, *SD* = 0.55, *Min* = 2; *Max* = 4). In the think-aloud protocol and coding of behavior (e.g., hesitation or moaning), the respondents exhibited a certain level of uncertainty in responding to questions on the frequency with which they participated in sport and physical activities.

Pre-study 2, "Test–retest study"

This pre-study aimed at testing the reliability of the retrospective statements on sport and physical activity in the life course. For this purpose, we conducted telephone interviews with the questionnaire twice on a total of 29 persons (17 women and 12 men) aged 23 to 75 years (M_{age} = 51.41, *SD* = 19.09). The average interval between the first and second interview was 95.07 days (*SD* = 15.34). For reliability testing, we calculated the values of Krippendorff's alpha. Krippendorff's alpha is similar to Scott's pi for a nominal scale and to Pearson's intraclass correlation coefficient for an interval scale. As suggested by Hayes & Krippendorff (2007), we conducted 10,000 bootstrap sampling distributions (CI = confidence interval). Except for the data on the frequency of participation in sport and physical activities and the data on competition participation in childhood and youth, all data have satisfactory reliability (see Table 1). As providing the data on the frequency of participation in sport and physical activities was already difficult for the respondents in the cognitive pretest, these data were excluded from further calculations, as were the data on competition participation in childhood and youth.

Interviewer training and pretest

The interviewers were trained prior to data collection by the LINK Institute for Market and Social Research, and they received support from full-time supervisors throughout the data collection process. The training focused on enabling the interviewers to provide assistance if respondents were uncertain, as well as to point out possible inconsistencies in content during the interview. The interviewers were supported in this respect by appropriate interviewer notes in the questionnaire.

The survey institute conducted a pretest of 20 interviews with persons aged 15 to 74 years to test the technical functionality of the questionnaire.

Check for consistency

The first step after data collection was to check the data for completeness. To do so, we began by examining logical missing values to check the aforementioned links in the questionnaire. Such logical missings appeared only in individual cases, but were then very pronounced. We thus did not consider imputation permissible and excluded these cases. The second step was to test the plausibility of the data via (cross-)comparison of the statements made by the respondents. For example, we analyzed the data respondents provided on the times of the particular LTPA episodes (exit from first active episode to start of second active episode). Furthermore, we checked the content of different items that provide similar information for consistency. For example, we made sure that the age of entry respondents provided for current sport and physical activities did not lie before their general entry to LTPA, or whether respondents with a general entry age of 15 years provided detailed information on LTPA in childhood and youth (e.g., organizational setting, competition participation). This check for consistency led to the exclusion of a total of *n* = 218 cases with contradictory data.

Design and Sample

This study is part of a project funded by the Swiss National Science Foundation and in collaboration with the federal survey "Sport Schweiz 2020." The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the University of Teacher Education, University of Applied Sciences and Arts Northwestern

Table 1
Values of the Krippendorff's alpha for the test–retest reliability (n = 29).

Variable	Scale	Krippendorff's alpha	
		Point estimate	Bootstrap 95%–CI[1]
Entering and exiting LTPA in life course			
First entry to LTPA in life course (age)	ratio	.81	.72 – .89
Interruption(s) of LTPA (longer than 1 year) in life course (yes/no)	nominal	.90	.70 – 1.00
Number of interruptions of LTPA in life course	ratio	.88	.67 – 1.00
Timing of interruptions of LTPA in life course (age)	ratio	.98	.94 – 1.00
Information per life stage			
Youth (until 20 years of age)			
Type of activities practiced	nominal	.95	.89 –.99
Frequency: days per week	ratio	.61	.38 – .82
Frequency: hours per week	ratio	.61	.43 – .77
Organizational setting	nominal	.93	.87 – .99
Competition participation	nominal	.73	.46 – 1.00
Young adulthood (21–30 years of age)			
Type of activities practiced	nominal	.93	.87 –.99
Frequency: days per week	ratio	.52	.14 – .82
Frequency: hours per week	ratio	.46	.05 – .78
Organizational setting	nominal	.90	.81 – .97
Competition participation	nominal	.93	.78 – 1.00
Middle adulthood (31+ years of age)			
Type of activities practiced	nominal	.90	.83 –.97
Frequency: days per week	ratio	.45	.01 – .80
Frequency: hours per week	ratio	.42	.02 – .77
Organizational setting	nominal	.81	.69 – .93
Competition participation	nominal	1.00	–

Note: Krippendorff's alpha is similar to Scott's pi for a nominal scale and similar to Pearson et al.'s intra-class–correlation coefficient for an interval scale (see Hayes & Krippendorff, 2007, for further information).

[1]As suggested (Hayes & Krippendorff, 2007), 10,000 bootstrap sampling distributions were performed (CI = confidence interval).

Switzerland (30 January 2019). A retrospective telephone survey with computer-assisted telephone interviews (CATI method) was conducted in 2019. The interviews lasted 25.5 minutes on average.

The random sample was recruited via the Federal Statistical Office (n = 569) and with persons from the panel of the survey institute (n = 950). The sample consists of 1,456 Swiss inhabitants aged 35–76 years. They were interviewed during 2019 (April–August). The mean age (M_{age}) was 60.5 ± 10.1 years, and n = 909 of the study cohort (62.4 %) were women (see Table 2).

In comparison with the population data of the Swiss Federal Statistical Office for the year 2019, the sample contains a somewhat higher number of women and persons with higher education. Persons with a foreign nationality are significantly underrepresented in the sample. In comparison with other national surveys on sport and physical activity behavior in Switzerland (especially Lamprecht et al., 2020; Storni et al., 2019), the sample shows a higher proportion of persons who stated that they participate regularly in LTPA.

Data analyses

For the description of LTPA over the life course, we first used descriptive methods (frequencies and percentages) and then subjected them to simple inferential statistical analyses (chi-square analysis using cross tabulation). We applied the Kaplan–Meier estimator to calculate the probabilities of entering or exiting LTPA as a function of the duration of episodes.

Results

LTPA over the life course may be described as cycles of activity and inactivity. For many respondents, an initial episode of LTPI is followed by an episode of LTPA. Only a very small proportion of the respondents (approx. 3%) did not participate in any sport or physical activities for their entire lifespan. Around 25 percent of the respondents exited the first LTPA episode and entered a second episode of LTPI. In contrast, around 73 percent of the respondents stated that they had always engaged actively in sports. On the whole, LTPA seems to be quite stable over the life course. There are relatively few transitions between LTPA and LTPI (5 entries or exits max.). Dropouts from LTPA occur less frequently across the particular episodes (approx. 20–40 percent of those active) than entries (approx. 80–98 percent of those inactive). In addition, it is striking that the LTPA episodes are maintained several years longer on average than the LTPI episodes. If the trajectory of LTPA shows a certain instability, however, the average duration decreases clearly after the third LTPA episode (see Table 3).

It is possible on the basis of the stability of LTPA to differentiate between several trajectories of LTPA (see Allmer, 2002): persons who are "always active," who entered a LTPA episode once and have never exited it; persons who are "never active or always inactive," who have never entered an LTPA episode that lasted over a year; and persons who show an unstable LTPA, meaning that their trajectory is characterized by at least one entry and exit (see Figure 1). As shown in Figure 1, the group of "always active" persons is the largest and the group of "never active" persons the smallest. In addition, the group of "always active" persons can be differentiated on the basis of age of entry to lifelong LTPA: the "always active early starters," who began their LTPA before the age of 20, and the "always active late starters," who did not participate in any LTPA before the age of 20 and started only later. Somewhat more than half of the respondents (approx. 59%) may be classified as belonging to the group of "always active early starters" (see Table 4).

The group with "unstable LTPA" is of particular interest for investigating the question of what influence the duration of episodes has on the probability of entries and exits (research question Q2). According to the definition of "unstable LTPA," all persons in this group have entered and exited at least one sport and physical activity over their life course. Figure 2 makes it clear that the risk of dropout is greater at the start of this first LTPA episode, both in women and in men, but that individual dropouts are also possible after many years of LTPA. The male respondents exit LTPA earlier than

Table 2
Description of the sample

	n	%
Total	1,456	
Sex		
Female	909	62.4
Male	547	37.6
Level of education		
Vocational training	703	48.3
Higher education entrance qualification & tertiary education	753	51.7
Age groups		
Under 55 years	439	30.2
56 years or older	1,017	69.8
Migration background		
Swiss nationality	1,361	93.5
Foreign nationality	95	6.5
Current LTPA		
Yes	1,362	93.5
No	94	6.5

Table 3
Episodes of leisure-time physical activity (LTPA) and inactivity (LTPI)

	Total	Exits		Duration [years]			
Episodes	***n***	***n***	**%**	***Mean***	***SD***	***Min***	***Max***
1st LTPI episode	1,456	1,413	97.05				
1st LTPA episode	1,413	349	24.70	39.85	17.69	1	71
2nd LTPI episode	349	314	89.97	6.48	8.88	1	53
2nd LTPA episode	314	91	28.98	15.93	13.44	1	61
3rd LTPI episode	91	79	86.81	2.80	3.64	1	27
3rd LTPA episode	79	32	40.51	13.44	10.51	1	42
4th LTPI episode	32	29	90.63	1.84	1.39	1	6
4th LTPA episode	29	6	20.69	6.72	5.30	1	21
5th LTPI episode	6	5	83.33	3.83	6.01	1	16
5th LTPA episode	5	1	20	7	5.20	2	14

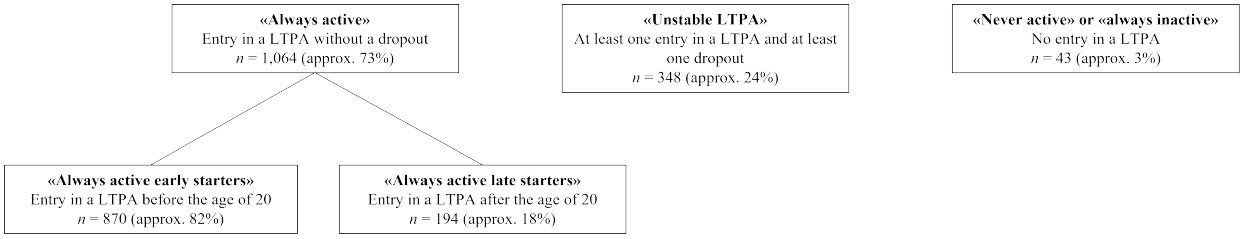

Figure 1 Groups of LTPA trajectories over the life course

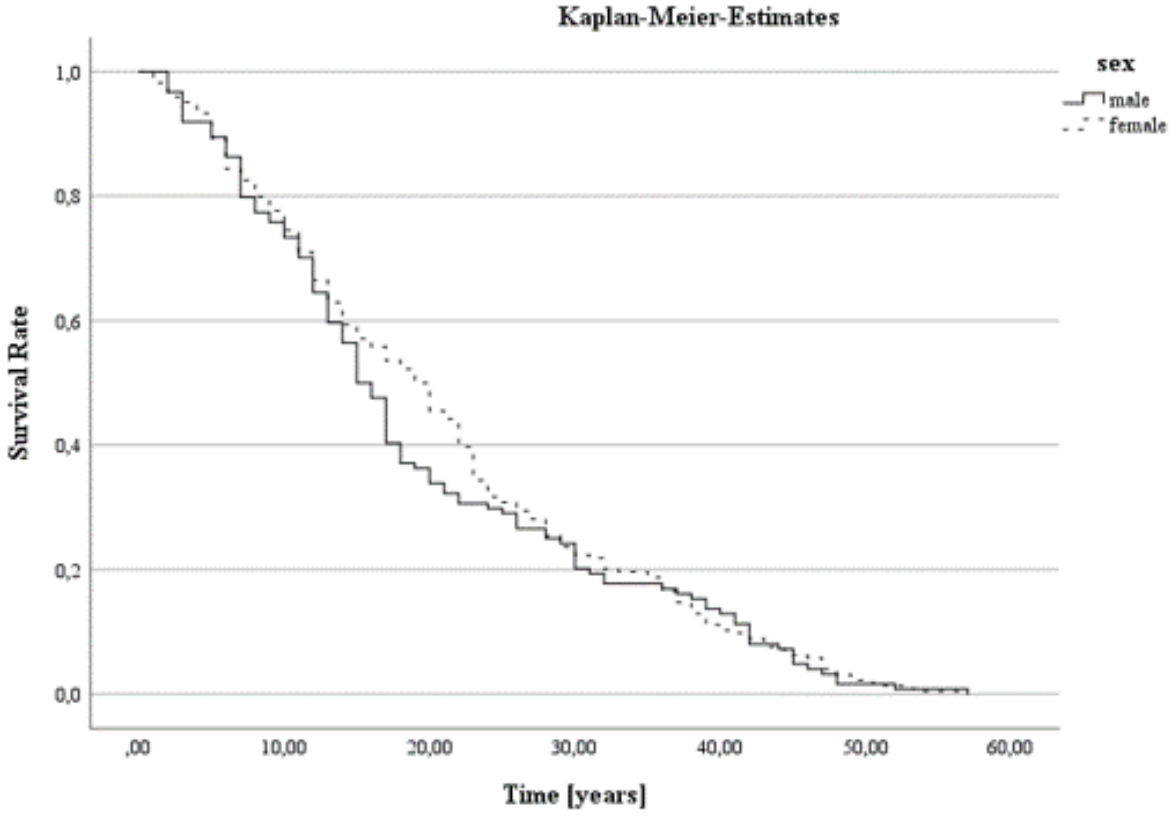

Figure 2 Risk of an exit from the first LTPA episode for the group with unstable LTPA; differentiated by sex (*n* = 348; male: *n* = 124; female: *n* = 224; Kaplan–Meier estimates)

the female respondents: After a duration of around 15 years, 50 percent of male respondents have already exited their first LTPA episode, whereas the median for women is around 19 years.

The phase of inactivity after the first LTPA episode is of relatively short duration (*M* = 6.48, see Table 3), and 50 percent of the respondents have already entered a second LTPA episode after around 3 years. Altogether, around 90 percent of the persons with "unstable LTPA" enter a second LTPA episode, from which every third

of them exits again. The respondents exit from the second LTPA episode somewhat faster than from the first one, with 50 percent already having exited it after around 12 years. For the episodes of inactivity in particular, the probability of entering an LTPA episode decreases significantly as episode duration increases. For LTPA episodes, the risk of an exit is somewhat greater at the start of the episode, but the probability of an exit does not decrease as much with increasing episode duration.

On the whole, the influence of socioeconomic factors on the four different life-course trajectories of LTPA may be regarded as low (see Table 4). The proportion of "always active late starters" is significantly lower among the younger respondents than among the older age cohort (adjusted standardized residual: -4.3). The same is true of the men: They too are statistically underrepresented in the group of "always active late starters" (adjusted standardized residual: -4.4). In the younger age cohort, the proportion of "never active" persons, who have never in their lives participated in an LTPA for longer than one year, is lowest (adjusted standardized residual: -3.4). The younger respondents more frequently show a more unstable LTPA trajectory (adjusted standardized residual: 4.0). If one looks at level of education, one sees that there are slightly fewer persons with higher education among the "always active late starters" (adjusted standardized residual: -3.4). Persons with higher education are more likely to belong to the group of "always active early starters." A somewhat higher amount of persons with a lower level of education have never entered an LTPA episode in their life course. (see Table 4).

Table 4
Different LTPA and LTPI trajectories differentiated by socioeconomic factors

	Total		Age				Sex				Education			
			35–55 years		56–76 years		Male		Female		Vocational training		Higher ed. entry qual., tertiary ed.	
LTPA trajectories	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
			(adj.stand. resid.)[1]		*(adj.stand. resid.)*		*(adj. stand. resid.)*		*(adj. stand. resid.)*		*(adj. stand. resid.)*		*(adj. stand. resid.)*	
Always active early starters	870	59.8	268	61.0	602	59.2	367	67.1	503	55.3	390	55.5	480	63.7
			0.7		-0.7		4.4		-4.4		-3.2		3.2	
Always active late starters	194	13.3	33	7.5	161	15.8	45	8.2	149	16.4	116	16.5	78	10.4
			-4.3		4.3		-4.4		4.4		3.4		-3.4	
Unstable LTPA	349	24	135	30.8	214	21.0	124	22.7	225	24.8	163	23.3	186	24.7
			4.0		-4.0		-0.9		0.9		-0.7		0.7	
Never active	43	3	3	0.7	40	3.9	11	2.0	32	3.5	34	4.8	9	1.2
			-3.4		3.4		-1.6		1.6		4.1		-4.1	
Total	1456	100	439	100.0	1017	100.0	547	100.0	909	100.0	703	100.0	753	100.0
			[2]Chi[2] (3, *N* = 1456) = 39,108, *p* < 0,0005, CI = 0,164				[2]Chi[2] (3, *N* = 1456) = 28,240, *p* < 0,0005, CI = 0,139				[2]Chi[2] (3, *N* = 1456) = 31,124 *p* < 0,0005, CI = 0,146			

[1] An adjusted standardized residual of more than 2.0 (or less than -2.0) can be interpreted as an indication that the number of cases is significantly larger (or smaller) than would be expected if the null hypothesis were true (see Agresti [2002] for further information).

[2] All expected cell frequencies were greater than 5.

In the following, we investigate the sport and physical activity-related history of the respondents. In doing so, we focus on the persons who were active in the long term or throughout their lifetimes to find possible stability factors (see Table 5). For this purpose, we consider LTPA in the three life stages childhood and youth (up to 20 years), young adulthood (up to approx. 30 years), and middle adulthood (from 31 years on).

In childhood and youth, the group of "always active late starters" was by definition not yet active. In comparison to the "always active early starters," the group with an unstable LTPA trajectory entered LTPA on average several years later. The "always active early starters" perform their sport and physical activities somewhat more frequently in a self-organized manner in childhood and youth than the group with an unstable LTPA trajectory. In young adulthood, the proportion of persons in the groups of "always active early starters" and "unstable LTPA" who participate in organized LTPA decreases. The proportion of self-organized performance increases only slightly in these two groups in young adulthood in comparison to childhood and youth. For the "always active late starters," who began their LTPA only after the age of 20, the organized performance of their sport and physical activity and competition participation in particular hardly play a role at all in young adulthood. In middle adulthood, self-organized LTPA gains importance across all groups; however, the increase is greatest in the "always active late starters." The proportion of organized LTPA in middle adulthood remains relatively stable in the groups of "always active early starters" and "unstable LTPA" in comparison to young adulthood, whereas an increase may be seen in the group of "always active late starters." Competition participation decreases slightly from young to middle adulthood in the "always active early starters" and the group with an "unstable LTPA." The "always active later starters," on the other hand, participate less often in competitions in comparison to the other two groups, but the proportion even increases slightly in middle adulthood. The most frequently performed activities both in the individual life stages and across all three groups of LTPA trajectories are walking und endurance activities and the outdoor and mountain activities typical of Switzerland. Sports games play a much smaller role for the "always active late starters," and they also become increasingly less important for the groups of "always active early starters" and "unstable LTPA," in particularly from childhood and youth to young adulthood. Fitness activities are the third most frequently performed activity in middle adulthood for the "always active late starters" and the group with "unstable LTPA" (see Table 5).

Discussion

The aim of this article was to describe LTPA trajectories as cycles of activity and inactivity over the life course, and in doing so to shed light on temporal dependencies. Contrary to the research findings available so far, which show a low to moderate stability of LTPA trajectories (Aggio et al., 2017; Beunen et al., 2004; Borgers et al., 2018; Engel & Nagel, 2011; Hirvensalo & Lintunen, 2011; Jekauc et al., 2018; Klostermann & Nagel, 2011; Kristensen et al., 2008; Malina, 2001; Telama, 2009; Trudeau et al., 2004), this study found a high stability. The large majority of the respondents show a long-term LTPA without interruptions over the course of years (research question Q1). This could be attributable, first, to historical changes in LTPA. The representative "Sport Schweiz" studies periodically conducted in Switzerland, for example, show a steady increase in LTPA in the past decades (Lamprecht et al., 2020). If one compares the proportion of sport and physical activities, however, it turns out that the proportion of 93.5 percent found in the present sample is higher than the 80 percent found in the "Sport Schweiz 2020." This indicates that the sample in the present study is a selective one, with a majority of individuals who engage actively in sports and exercise. Second, the high stability of the individual LTPA trajectories found in the present study could be attributable to the fact that respondents in a retrospective survey tend, in a kind of autobiographical smoothing, to remember their sport and physical activity better than the interruptions (for educational and occupational trajectories

Table 5
Characteristics of sport- and physical activity-related history differentiated by the groups of LTPA trajectories

	Always active early starters (*n* = 870)	**Always active late starters (*n* = 194)**	**Unstable LTPA (*n* = 349)**
Age of entry into LTPA			
Mean (SD)	10.40 (4.84)	35.37 (12.36)	13.28 (9.21)
Min	3	21	3
Max	20	71	55
Life stage of childhood/youth			
LTPA (*n; %)*	870 (100%)	-	312 (89.4%)
Sport and physical activities (*n; %)*	1. Walking and endurance activities (*n* = 618; 71%) 2. Outdoor and mountain activities (*n* = 519; 59.7%) 3. Sports games (*n* = 320; 36.8%)	-	1. Walking and endurance activities (*n* = 195; 55.9%) 2. Outdoor and mountain activities (*n* = 164; 47%) 3. Sports games (*n* = 123; 35.2%)
Organizational setting		-	
Organized (*n; %*)	626 (72%)	-	249 (71.3%)
Self-organized (informal [*n; %*])	595 (68.4%)	-	176 (50.4%)
Life stage of young adulthood			
LTPA (*n; %)*	870 (100%)	118 (60.8%)	313 (89.7%)
Sport and physical activities	1. Walking and endurance activities (*n* = 594; 68.3%) 2. Outdoor and mountain activities (*n* = 470; 54%) 3. Sports games (*n* = 213; 24.5%)	1. Walking and endurance activities (*n* = 80; 41.2%) 2. Outdoor and mountain activities (*n* = 60; 30.9%) 3. Gymnastics and multi-sport activities (*n* = 25; 12.9%)	1. Walking and endurance activities (*n* = 192; 55%) 2. Outdoor and mountain activities (*n* = 137; 39.3%) 3. Sports games (*n* = 73; 20.9%)
Organizational setting			
Organized (*n; %*)	445 (51.1%)	46 (23.7%)	167 (47.9%)
Self-organized (informal [*n; %*])	627 (72.1%)	96 (49.5%)	194 (55.6%)
Competition participants (*n; %*)	292 (33.6%)	18 (9.3%)	79 (22.6%)
Life stage of middle adulthood			
LTPA (*n; %)*	870 (100%)	194 (100%)	332 (95.1%)
Sport and physical activities	1. Walking and endurance activities (*n* = 739; 84.9%)	1. Walking and endurance activities (*n* = 160; 82.5%) 2. Outdoor and mountain activities (*n* = 116; 59.8%)	1. Walking and endurance activities (*n* = 276; 79.1%)

	Always active early starters (*n* = 870)	**Always active late starters (*n* = 194)**	**Unstable LTPA (*n* = 349)**
	2. Outdoor and mountain activities (*n* = 570; 65.5%) 3. Sports games (*n* = 197; 22.6%)	3. Fitness (*n* = 60; 30.9%)	2. Outdoor and mountain activities (*n* = 197; 56.4%) 3. Fitness (*n* = 93; 26.6%)
Organizational setting			
Organized (*n; %*)	424 (48.7%)	80 (41.2%	165 (47.3%)
Self-organized (informal [*n; %*])	770 (88.5%)	170 (87.6%)	277 (79.4%)
Competition participants (*n; %*)	216 (24.8%)	22 (11.3%)	62 (17.8%)

cf. Matthes et al., 2007). Nevertheless, there are also several LTPA trajectories in the sample with multiple entries and exits. This shows, as in Engel & Nagel (2011), that the probability of an event occurring, in particular the chance of a (re)entry, decreases with increasing duration of the episode (research question Q2). The probability of an exit during the LTPA episodes does not decrease as much, and there is still a risk of exit even after many years of LTPA.

In accordance with our theoretical framework, the life course research approach (Bernardi et al., 2019; Mayer, 1990, 2009), we analyzed sport and physical activity-related history to determine possible advantageous conditions for long-term LTPA over the life course (research question Q3). The present state of research indicates that both the particular sport and physical activities and the organizational setting have an influence on the stability of LTPA over the life course (e.g., Klostermann & Nagel, 2011; Telama, 2009). In the present study, however, we found only slight differences when comparing the LTPA trajectory groups of "always active early starters and late starters" and "unstable LTPA." The "always active early starters," who maintain LTPA longest, enter slightly earlier on average and show a slightly higher proportion of self-organized performance even in childhood and youth. Self-organization in particular could be interpreted as a possible success factor for long-term LTPA, as this organizational practice becomes increasingly important in the later stages of life (e.g., Eime et al., 2015, 2020), and it could therefore be advantageous to have gained experience with it at an early age (e.g., Lunn, 2010; Telama, 2009).

The influence of socioeconomic factors on LTPA has been widely documented in cross-sectional studies (e.g., Lamprecht et al., 2020; Rohrer & Haller, 2015) as well as in several longitudinal studies (e.g., Hirvensalo & Lintunen, 2011). We also included several socioeconomic variables in the analysis of long-term LTPA trajectories in the present study (research question Q4). As already demonstrated by Breuer (2003), women tend to enter LTPA at a later point and maintain it over the course of several years. In the present study, too, women are also statistically overrepresented in the group of "always active late starters." In addition, although the younger age cohort of 35- to 55-year-old persons seems to have done a good job overall entering LTPA episodes, since they are hardly represented at all in the "never active" group, they are at the same time represented in a higher proportion in the "unstable LTPA" group. Time-series studies, as well as initial longitudinal studies on LTPA, also point to historical changes in LTPA (e.g., Klostermann & Nagel, 2014; Lamprecht et al., 2020): Younger age cohorts engage more frequently in sport and physical activi-

ties, and the somewhat more unstable trajectories of the younger age cohorts could also be explained by the flexibilization of the entire life course in society as a whole.

Limitations and prospects

The findings of the present study should nevertheless be interpreted with caution in view of several limitations. We made various efforts (e.g., by making reference to the established and recognized Sport Schweiz 2020 study and by recruiting the sample using data from the Swiss Federal Statistical Office) to recruit a representative sample. This is a methodological challenge for many population surveys, and attempts to overcome it in the past years have not yet been successful in all respects. This limitation should be taken into account, but analyses of possible advantageous conditions of long-term or lifelong LTPA are also possible with a somewhat selective sample. However, future empirical studies should make further efforts in this direction, such as compensation for participation (e.g., Berger, 2006; Pforr & Rammstedt, 2016) or a mix of methods (e.g., not only the CATI method but also face-to-face interviews), to also obtain findings about the group of persons who engage in little to no LTPA.

The present study undertook several measures to further develop and check retrospective data collection of lifetime LTPA trajectories. We succeeded in supporting the recall of the respondents through the methods applied, and the data appear to be reliable. However, future studies could implement further recall aids, particularly visual aids (e.g., event history calendar), or further individualize the questionnaires by means of innovative questionnaire programming.

The focus of the present study is on the description of trajectories of LTPA over the entire life course. It is like a wide-angle view: you can see the entire life, but you cannot observe the details. As Bernardi et al. (2019, p. 4) state, "the longer lives are studied, the more difficult it becomes to trace connections […]. It is hard to know which variables are important, when they are important […]". There is still demand for research examining theoretically as well as empirically the temporal causality of LTPA during the life course. More specific theories related to the causality behind the observable LTPA behavior of human beings are still needed (e.g., resource-related explanatory approaches).

Due to the quantitative nature of the present study, it aimed in particular at portraying LTPA trajectories maintained in the long term. For the task of analyzing the temporal dependencies of LTPA over the life course in detail, the additional step of conducting qualitative analyses of theoretically selected cases would appear conducive to further insights (e.g., with a biographical approach). Quantitative surveys are only of limited use for measuring complex temporal dependencies across various time dimensions.

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Competing interests

The authors have declared that no competing interests exist.

Data availability statement

Datasets will be available at SWISSUbase upon acceptance of the manuscript.

A Appendix: Extract of the questionnaire (CATI-Survey)

Wording and response categories of questions regarding current and previous sport and physical activity.

A.1 Part A: Current sport and physical activity

Question A1: Do you practice sport?

Sport in this context means any kind of sport, gymnastics, or fitness activities.

Response categories: yes, no

Question A1.1: If "yes": How often do you practice?

Response categories: (almost) daily, several times a week, about once a week, once to three times a month, less than once a month, never

Question A1.2: If "at least once to three times a month": How many hours per week approximately?

Response categories: hours per week

Question A2: Which sport and physical activity do you practice?

Open response; max. 10 different sport and physical activities

For each mentioned sport and physical activity following questions were asked:

Question A2.1: How many days per year do you practice sport or physical activity X?

Response categories: days per year

Question A2.2: How many hours per training day do you practice the sport or physical activity X on average?

Response categories: hours per day

Question A2.3: How is the sport or physical activity X organized?

Response categories (multiple responses): organized in a sport club, organized in a fitness center, organized by the school, organized by another private sport provider (e.g., Dance studio), organized and leaded sports facilities (e.g., fixed walking or running groups), self-organized and unleaded

Question A2.4: Since when do you practice the sport or physical activity X?

Response categories: year of age or calendar year

A.2 Part B: Previous sport and physical activity

Sport and physical activity in childhood and youth (i. e. until the age of 20 years)

If respondent have mentioned sports and physical activity with the beginning during childhood and youth previously: You have mentioned already that you practiced following sport and physical activity in childhood and youth… (A list of all sport and physical activities already mentioned in the interview that were entered at the particular life stage and practiced regularly (= at least once a week) were automatically transferred).

Question B1: Did you practice regularly (i.e., at least once a week) further sport and physical activities in childhood and youth?

Response categories: yes or no

Question B1.1: If yes: which further sport and physical activities did you practice during your childhood and youth?

Open response: max. 5 different sport and physical activities

If respondent have not mentioned sports and physical activity with the beginning during childhood and youth previously:

Question B2: Did you practice sport and physical activities regularly (i.e., at least once a week) in childhood and youth (i.e., until the age of 20 years)?

Response categories: yes or no

Question B2.1: If yes: which activities?

Open response: max. 5 different sport and physical activities

Question B3: How many days per week did you practice all the mentioned activities on average during childhood and youth?

Response categories: days per week

Question B4: How many hours per week did practice all the mentioned activities on average during childhood and youth?

Response categories: hours per week

Question B5: How were the mentioned activities organized?

Response categories (multiple responses): organized in a sport club, organized in a fitness center, organized by the school, organized by another private sport provider (e.g., Dance studio), organized and leaded sports facilities (e.g., fixed walking or running groups), self-organized and unleaded

Question B6: Did you compete during the childhood and youth?

Response categories: yes or no

The same questions were asked for the period "young adulthood" (i. e. between the age of 20 and 30 years) and the period "middle adulthood" (i.e. after the age of 30 years).

A.3 Part C: Interruption of the sport and physical activities

Question C1: How old were you when you have started practicing regularly sport and physical activities?

Response categories: year of age or calendar year

Question C2: Did you ever interrupt your sport and physical activity longer than one year?

Response categories: yes or no

Question C2.1: If yes: How many interruptions of your sport and physical activity (longer than one year) can you remember?

Response categories: 1 interruption, 2 interruptions, 3 interruptions, 4 interruptions, 5 interruptions or more

Question C2.2: For each interruption (max. 5): when started the interruption and when ended it?

Response categories: year of age or calendar year

Appendix B: Manuscript 2

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The role of leisure-time physical activity in youth for lifelong activity—a latent profile analysis with retrospective life course data

Supplementary Information

The online version of this article (https://doi.org/10.1007/s12662-023-00884-9) contains supplementary material, which is available to authorized users.

Introduction

Promoting regular and long-lasting leisure-time physical activity (LTPA) for a wide range of the population is a goal among various societal actors given the long-term health-promoting effects (Reiner, Niermann, Jekauc, & Woll, 2013) and the high health costs caused by physical inactivity (Ding et al., 2016). For this purpose, youth is a decisive life stage to shape later health behaviour (Sawyer et al., 2012) including lifelong LTPA (Kirk, 2005), which is supported by the general life course approach (Bernardi, Huinink, & Settersten, 2019). Time-related interdependencies over the life course are assumed, which means that not only the recent past influences the present but also the far-away past (see *path dependency* in Bernardi et al., 2019). Hence, no single time points or single selected explanation factors can be examined; rather, their various interdependencies must be examined. Thus, it is important to consider a long period in order to understand and explain later outcomes in life. However, in studies investigating the association between differentiated factors of LTPA in youth and later LTPA in life, the measurement of lifelong LTPA was mostly recorded for only one time point in (young) adulthood. Thus, there is no information on long-term or even lifelong LTPA throughout adulthood. Another characteristic of the life course approach is the amount of time spent in certain situations, which is highly relevant for the further course of life (Mayer, 1990) and for LTPA: the longer continuously active in life, the lower the chance of becoming inactive (Engel and Nagel, 2011). Persistent exercising for at least three years in youth is a predictor for being later active in life (Batista et al., 2019). In addition, a long physically active period in youth can also be achieved by early entry into LTPA, which is also predictive for later LTPA in life (Kjønniksen, Anderssen, & Wold, 2009). The aforementioned time-related high involvement in LTPA, also referred to as the depth of activities, can be further supported by a high weekly frequency of LTPA in youth, which seems relevant for later LTPA in life as well (Batista et al., 2019).

In addition to time-related aspects, from a human development perspective, the context plays a decisive role to understand and explain behaviour and development (e.g. Lerner, 2006). This is also shown for LTPA in youth: specific types of activities (e.g. endurance sports, Kjønniksen, Anderssen, & Wold, 2008; Tammelin, Näyhä, Hills, & Järvelin, 2003), organised and often club-based activities (Kjønniksen et al., 2009; Scheerder et al., 2006), self- and non-organised activities (Cleland, Dwyer, & Venn, 2012; Scheerder et al., 2006) and competitions (Batista et al., 2019) are related to LTPA later in life. The number of different contexts represented by the number of different activities in youth, also called breadth of activities, is also promising for LTPA later in life (Engström, 2008; Cleland et al., 2012; Kjønniksen et al., 2008). Consequently, individuals choose environments to participate in LTPAs in specific contexts, which leads to multiple combinations of activities and the exposure to various contexts (Agans and Geldhof, 2012). Thus, there is not only one LTPA in one context in youth for conducive development (cf. Coakley, 2011); rather, activities and contexts are interrelated, and thus interactions within individuals occur (e.g. football can be played

Data availability statement
The data that support the findings of this study are available from the corresponding author, [LL], upon reasonable request.

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in a club or self-organised; cf. Gut, Schmid, & Conzelmann, 2020, Zarrett et al., 2009). There are various such constellations in a population, i.e. interindividual differences (e.g. some play football in a club, others play self-organised and others do both; e.g. Zarrett et al., 2009). Consequently, analysing separate variables or predictors of LTPA in youth fall short, also due to including only aggregate values on group levels (cf. Zarrett et al., 2009) and thus neglecting possible compensation effects (e.g. high values in certain variables can counterbalance low levels in other variables for lifelong LTPA) and synergistic effects (e.g. high levels of variables strengthen each other for lifelong LTPA) within an individual. Therefore, the person-oriented approach describing patterns of LTPA in youth seems promising (Bergman, Magnusson, & El-Khouri, 2003). Empirical studies that describe such patterns of LTPA in youth differ regarding the variables used for person-oriented analyses: (1) specific types or categories of activities (Agans and Geldhof, 2012; Borgers et al., 2015); (2) organisational settings differentiating between organised and self-organised settings (Gut et al., 2020; Gut, Schmid, Imbach, & Conzelmann, 2022; Lawler, Heary, & Nixon, 2017); and (3) the breadth (number of different activities) and depth (frequency/duration of activities) of activities (Agans, Johnson, & Lerner, 2017). Klostermann and Nagel (2011) included the breadth and depth as well as the organisational setting but for the first 39 years of life—not in youth. However, the reported studies investigated patterns of LTPA in youth (except Klostermann and Nagel, 2011) but not the relationship with lifelong LTPA.

Several attempts at explanation were made to explain the relationship between LTPA in youth and lifelong LTPA. Telama (2009) formulated therefore hypotheses. For example, the *carry-over value hypothesis* means that specific types of physical activities learned in early years are continued in adulthood, also called lifestyle activities. In addition, the *ability and readiness hypothesis* indicates that early experiences of activities with basic skills facilitate the continuation of being physically active or to re-enter in the same or other activities. This hypothesis from Telama is similar to the early sampling approach (Côté, Baker, & Abernethy, 2007), not for achieving later success in one activity but for later recreational participation, or in other words, for lifelong activity. Therefore, experiences with a broad range of activities ('sampling') in youth helps during the life course to start new activities, to continue given activities or to re-enter already practiced activities.

In summary, when investigating the relationship between LTPA in youth and lifelong LTPA, the following research desiderata should be considered: (1) no single time points or single selected explanation factors but rather the entire life course and interdependencies between time and explanation factors, (2) time-related and context-related information to represent LTPA behaviour in youth and (3) person-oriented analysis methods allowing for intra- and interindividual interactions and differences. Moreover, (4) sociodemographic aspects such as sex, educational level and age are well-known differentiation aspects of LTPA in youth (e.g. for Switzerland: Lamprecht, Bürgi, & Stamm, 2020) and should thus be taken into account. In this study, the aforementioned research desiderata are considered and three research questions (RQ) are defined:

RQ 1: Which patterns of time-related and context-related information about LTPA emerge in youth?

RQ 2: How can the emerged patterns further be described in regard to sociodemographic variables and specific types of LTPAs?

RQ 3: To what extent are the patterns from youth associated with lifelong LTPA?

Materials and methods

Design and sample

This study is part of a project funded by the Swiss National Science Foundation and in collaboration with the federal survey "Sport Schweiz 2020". LTPA over the whole life course was recorded with a retrospective and validated questionnaire. More precisely, a retrospective telephone survey with computer-assisted telephone interviews (CATI method) of Swiss inhabitants aged between 25 and 76 years was conducted in 2019. The random sample was recruited via the Federal Statistical Office and with persons from the panel of the survey institute. The questionnaire used is a further development of previous studies investigating LTPA during the life course (e.g. Klostermann and Nagel, 2011) and was tested qualitatively and quantitatively in multiple waves, including a separate reliability check with the test–retest method ($n = 29$; for a detailed description for the validation of the questionnaire, see Lenze, Klostermann, Lamprecht, & Nagel, 2021). Using Krippendorff's α to consider multiple scale levels for the reliability check, all variables used showed good values ($\alpha > 0.80$; Krippendorff, 2018; see specific values in Supplementary Table 1).

After conducting the survey, the data of each participant were checked carefully for internal consistency and discrepancies, which led to the exclusion of 222 participants, resulting in a final sample of $n = 1519$ ($n = 569$ from the Federal Statistical Office; $n = 950$ from the panel of the survey institute).

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the University of the University of Teacher Education, University of Applied Sciences and Arts Northwestern Switzerland (30 January 2019). Informed consent was obtained from all subjects involved in the study.

Measures

LTPA is understood as physical activities including exercise, sport and unstructured recreation and excludes domestic, occupational, and commuting physical activity (Khan et al., 2012; see Lenze et al., 2021 for a detailed description). In this article, the term *youth* relates to the first 20 years of one's life. To build patterns of LTPA behaviour in youth (RQ 1), four indicators considering time-related and context-related information were included and recorded up to the age of 20:

Number of regularly active years. The depth of activities was measured by regularly active years in terms of LTPA between 3 and 20 years of age. The term 'regular' refers to at least once a week. Thus, each regularly active year in the aforementioned age range was added per participant.

Number of different activities practiced. To cover the breadth of activities, each LTPA practiced at least multiple times per year for more than one year was included. The maximum number of different LTPAs was set to five.

Self-organised activities. LTPAs practiced regularly by oneself or with friends reflect one part of the organisational setting. This indicator was dummy coded if this organisational form was practiced (1) or not (0) in youth. The term 'self-organised' is equivalent to 'informal' or 'non-organised'.

Organised activities. Regular club-based LTPAs or at private sports providers (e.g. fitness centre, yoga or dance studio) comprise this part of the organisational setting. This was coded as a dummy variable if activities were practiced organised (1) or not (0) in youth.

To enrich the patterns with further relevant information regarding aspects affecting LTPA behaviour (RQ 2), sociodemographic variables and categories of specific types of LTPAs were included. *Sex, age at the time of the survey* and *educational level* were considered. The educational level is represented by a 5-level variable (1 compulsory school; 2 secondary school/lower professional education; 3 higher professional education leaving certificate; 4 technical college; 5 university). To provide insights into which types of LTPA were practiced in the respective pattern, ten *categories of types of LTPAs* from Sudeck, Lehnert, & Conzelmann (2011) were used (1 walking and endurance activities; 2 fitness; 3 gymnastics and multisport activities; 4 athletics; 5 compositional–creative activities; 6 release-oriented activities; 7 outdoor- and mountain activities; 8 sports games; 9 martial arts; 10 equestrian).

Abstract

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L. Lenze · C. Klostermann · J. Schmid · M. Lamprecht · S. Nagel

The role of leisure-time physical activity in youth for lifelong activity—a latent profile analysis with retrospective life course data

Abstract

Considering the positive health effects of leisure-time physical activity (LTPA), youth is an important life stage to promote lifelong LTPA. However, the stability of LTPA over the life course is low, and specific predictors of LTPA in youth for lifelong activity have some shortcomings, e.g. neglecting the interacting factors of LTPA within individuals. Therefore, from a person-oriented approach, patterns of LTPA behaviour in youth considering time- and context-related aspects and their relationships with lifelong LTPA were investigated. Life course data from $n = 1519$ Swiss inhabitants aged between 25 and 76 years were recorded retrospectively using a validated questionnaire (CATI method). *Latent profile analyses* were used to find the optimal profile solution and for the association with lifelong LTPA *auxiliary conditional effect models* (controlled for age) were applied. Six distinct patterns emerged. Overall, mostly inactive youth are also the least active in adulthood, whereas several other patterns are associated with a mainly continuous LTPA throughout adulthood. More precisely, multiple constellations in youth occurred to be physically active in at least 80% of the years in adulthood: (1) early starters regarding LTPA in a rather self-organised setting but not with many different LTPAs; (2) late entrants with a variety of different activities and organisational settings; or (3) a high expression in every variable investigated. Consequently, there is not just one type of LTPA behaviour in youth linked to lifelong activity, which indicates that certain aspects of LTPA in youth can be compensated by each other. Implications for LTPA promotion can be derived.

Keywords

Sport participation · Youth development · Person-oriented approach · Pattern · Time-related and context-related aspects

Concerning lifelong LTPA (RQ 3), an *index of lifelong LTPA* with the ratio of physically active and inactive years in adulthood was developed for each participant. Due to the broad age range at the time of the survey, a comparable score was calculated from 21 years until the age at time of the survey of each person (ratio of regularly active years divided by the years of life from 21 upwards). This index reflects LTPA throughout adulthood.

Data preparation and analyses

To identify patterns of LTPA in youth (RQ 1), latent profile analyses (LPA) with four indicators were conducted (Masyn, 2013). This procedure allows to integrate continuous and categorical variables as indicators. In this study, two indicators (*number of regularly active years* and *number of different activities practiced*) were used as continuous variables, whereas the other two indicators (*self-organised activities* and *organised activities*) were applied as categorical variables. One to eight profiles were calculated. To find the optimal number of profiles, a mix between content-related and statistical criteria were used. The content-related criteria included theory-based considerations, clear qualitative differences between profiles, the principle of parsimony and a lack of small profiles (< 5% of the sample) (Masyn, 2013; Morin and Wang, 2016). In contrast, the statistical criteria comprised the screening of the log likelihood value (LL), Akaike information criterion (AIC), consistent AIC (CAIC), Bayesian information criterion (BIC), sample-sized adjusted BIC (SABIC), bootstrap likelihood ratio test (BLRT) and the Vuong–Lo–Mendell–Rubin likelihood ratio test (VLMR) (Marsh, Lüdtke, Trautwein, & Morin, 2009; Masyn, 2013; Morin and Wang, 2016). Due to large sample sizes, adding a profile often yields significant BLRT and VLMRT as well as lower AIC, CAIC, BIC, and SABIC values (Marsh et al., 2009). Thus, the separate fit-indices provide no adequate measures

Fig. 1 ◀ Plots of the six profiles. The left-sided y-axis displays *z*-scores of the first two indicators (number of regularly active years and number of different activities practiced), whereas the right-sided y-axis shows the percentages of people who practiced LTPA in this organisational setting for the third (self-organised activities) and fourth (organised activities) indicators

and the elbow plot of the fit-indices must be taken into account (Morin & Wang, 2016). For the further description of the patterns (RQ 2), the means of the sociodemographic variables (sex, age, educational level) per pattern were taken and the Wald test was used to identify significant differences between the patterns (p-value < 0.01). The interpretation of the differences between the patterns was further described by effect sizes (Cohen's d: ≥ 0.20 small effect, ≥ 0.50 medium effect, ≥ 0.80 large effect; Cohen, 1988).

To model the relationship between profile memberships and the index of lifelong LTPA controlling for age, auxiliary conditional effects models (similar to an ANCOVA, McLarnon and O'Neill, 2018) were applied. Controlling for age was important as age-related differences in the life course can occur, which is already partly considered in the index of lifelong LTPA. To interpret the mean differences between profiles, again the Wald test indicated significance (p-value < 0.01), and the Cohen's d indicated effect size. All analyses were performed with Mplus (Muthén and Muthén 1998–2017) using the maximum likelihood estimation with robust standard errors.

Results

Sample characteristics

The mean age at the time of the survey of the $n = 1519$ participants was 59.2 ± 11.75 years and 947 women (62.3%) were in the sample. Regarding the educational level, the mean of the 5-level scale (1–5) was exactly 3 ± 1.22. Further general sample characteristics can be found in Supplementary Table 2. The means of the indicators and the index of lifelong LTPA are presented in Supplementary Table 3. Regarding the specific types of LTPAs, the first two columns in Supplementary Table 4 reflect the frequencies in the ten categories.

The optimal profile solution

In a first step, the optimal number of profiles had to be determined. Therefore, the fit-indices for one to eight profiles

Table 1 Description of the six profiles with indicators for the latent profile analysis (LPA) and further descriptive values ($n = 1519$)

Variables	Profile 1	Profile 2	 Profile 3	 Profile 4	 Profile 5	 Profile 6	Entire sample
n (%)	293 (19.3%)	473 (31.1%)	117 (7.7%)	187 (12.3%)	220 (14.5%)	229 (15.1%)	1519 (100%)
Four indicators for the LPA							
Number of regularly active years (0–18)	0.05	13.53	5.29	13.62	3.46	11.54	8.5
Number of different activities practiced (0–5)	0.32	4.41	4.19	1.92	1.94	1.93	2.55
Self-organised activities[a] (%)	2.9	77.6	73.9	> 99	62.3	0.9	53
Organised activities[a] (%)	0.2	89.4	77.6	37.9	51.1	> 99	61
Sociodemographic values[b]							
n female (%)	226 (77.1)	275 (58.1)	60 (51.3)	142 (75.9)	120 (54.5)	124 (54.1)	947 (62.3)
Age (at time of the survey)	63.37	55.78	59.86	59.59	60.84	58.88	59.2
Educational level (1–5)	2.54	3.27	3.11	2.9	2.93	3.16	3.0

Means per profile are provided, the last column relates to the means of the whole sample to compare the values better directly from the profiles. Additional descriptive information for the whole sample can be found in Supplementary Table 1 and Supplementary Table 3

[a]The percentages mean the proportion of people practicing leisure-time physical activity (LTPA) in the given organisational setting compared to not practicing LTPA in this setting. This is equivalent to the probability of practicing LTPA in this organisational setting

[b]Statistical differences of the sociodemographic values between the respective profiles are shown in Supplementary Tables 6–8

are shown in Supplementary Table 5. In Supplementary Fig. 1, the fit-indices are plotted and the best-fitting solution is provided by the profile after which the slope flattens out. Therefore, five to seven profiles seemed to fit best. Considering content-related criteria, in terms of parsimony the five-profile solution would have been favoured. But regarding the qualitative differences within profile solutions, the six-profile solution showed more distinct patterns (**Fig. 1**) in comparison to the five and seven profile solutions (not shown). Furthermore, rather in the six-profile solution than in the five-profile solution theoretically plausible profiles emerged, and no profiles with less than 5% of the sample occurred. Altogether, the six-profile solution was seen as the best-fitting solution considering all criteria mentioned. This solution also showed a high value of the classification precision (Entropy = 0.86; see Supplementary Table 5).

Description of the profiles

Based on RQ 1, the six profiles are plotted in **Fig. 1**. **Table 1** shows per profile values of the indicators and sociodemographic information, and the categories of types of LTPAs are presented in Supplementary Table 4 (RQ 2).

In the following paragraphs, each profile is described by indicators (RQ 1) and further variables (RQ 2). Regarding the sociodemographic information as further variables, the significant differences and effect sizes between the profiles are shown in Supplementary Tables 6–8. Overall, despite a lot of significant differences between the profiles which might be caused by the large sample size, the effect sizes were negligible to small. Only one difference per sociodemographic variable revealed a moderate effect size (Supplementary Tables 6–8).

Profile 1 is called *mostly inactive youth* and includes participants who were inactive or very low active in youth. Compared to the other profiles, more women are in this profile, they are on average older, and lower educated. The *very diversely active early starters* reflect profile 2. This largest profile contains high and above-average values for all indicators. Thus, people of this profile started early in life with regular LTPAs and practiced several different activities in organised as well as self-organised settings. They are on average younger, higher educated and practiced each category of specific types of LTPAs above-average, especially walking and endurance activities, outdoor- and mountain activities and sports games. Profile 3 includes the *very diversely active late entrants*. This profile is quite similar to profile 2 with one difference: People in profile 3 did not have that many regularly active years during youth and are therefore called late entrants. Furthermore, in comparison to the other profiles, they are very often men and showed a very similar distribution of specific types LTPAs practiced as profile 2. The *low diversely active, self-organised early starters* in profile 4 began very early with regular LTPA but did not practice many different LTPAs in a self-organised and in a partially organised setting. Compared to the other profiles, many women are in this profile, and they were predominantly active in walking and endurance activities as well as outdoor- and mountain activities, but not frequently in sports games. Profile 5 represents the *low diversely active late entrants*. This profile is characterised by few regularly active years in few different LTPAs (primarily walking and endurance activities and outdoor- and mountain activities) partially practiced in self-organised and organised settings. Profile 6 is the *low diversely active, organised early starters*. People in this profile practiced few different LTPAs in an organised setting and entered LTPA rather early in youth. They practiced mainly sports games and comparatively

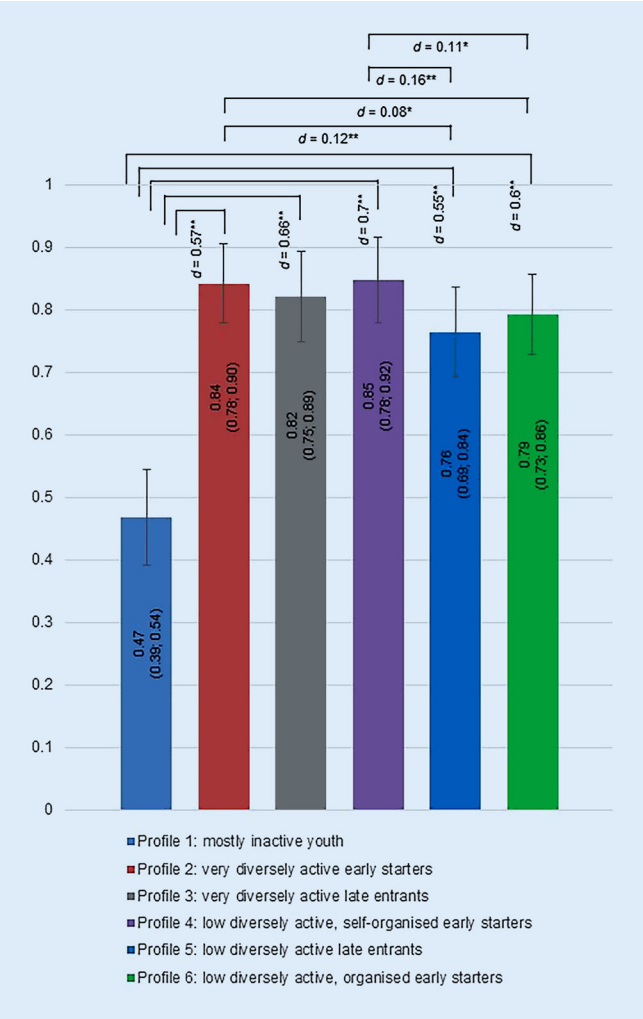

Fig. 2 ◀ Means and 95% confidence intervals of the *Index of the lifelong LTPA* per profile, controlled for age. Comparisons between profiles contain the significance levels *$p < 0.01$, **$p < 0.001$ and effect sizes of Cohen's *d*

less walking and endurance activities or outdoor- and mountain activities.

Association between the profiles and lifelong LTPA

Regarding RQ 3, ◘ **Fig. 2** reveals the *Index of lifelong LTPA* per profile including significant differences and effect sizes, controlled for age. The most active people in adulthood were the *low diversely active, self-organised early starters* (profile 4, index = 0.85) and the *very diversely active early starters* (profile 2, index = 0.84). They were significantly more active than people from profile 1 with a medium effect size (for profile 4: $p < 0.001$, $d = 0.7$; for profile 2: $p < 0.001$, $d = 0.57$) and also significantly more active with a very small effect size than people from profile 5 (for profile 4: $p < 0.001$, $d = 0.16$; for profile 2: $p < 0.001$, $d = 0.12$) and profile 6 (for profile 4: $p < 0.01$, $d = 0.11$; for profile 2: $p < 0.01$, $d = 0.08$). Also mostly active in adulthood were the *very diversely active late entrants* (profile 3, index = 0.82), the *low diversely active, organised early starters* (profile 6, index = 0.79) and the *low diversely active late entrants* (profile 5, index = 0.76). They were all significantly more active with a medium effect size compared to people from profile 1 (for profile 3: $p < 0.001$, $d = 0.66$; for profile 6: $p < 0.001$, $d = 0.6$; for profile 5, $p < 0.001$, $d = 0.55$). The *mostly inactive youth* (profile 1) had the lowest activity ratio in adulthood (index = 0.47).

Discussion

The present study investigated the LTPA behaviour in relation to time- and context-related aspects in youth and the association to lifelong LTPA in adulthood. Using retrospective life course data with a validated questionnaire and a person-oriented approach, qualitatively distinct patterns of LTPA in youth emerged. These patterns are related to different levels of lifelong LTPA in adulthood.

Patterns of LTPA in youth

Time- and context-related aspects of LTPA in youth were applied to build patterns of LTPA behaviours. In the person-oriented approach used, the relevant variables can interact within individuals and can differ between individuals (Bergman et al., 2003), describing the heterogeneity of LTPA behaviours occurring in youth by identifying homogeneous subgroups (e.g. Gut et al., 2020). Based on the profiles, similarities to other studies can only be identified to a certain extent as the indicators used have never been studied in this context. Nevertheless, the *mostly inactive youth* (profile 1) emerged in other studies as well (Agans et al., 2017; Gut et al., 2020, 2022; Lawler et al., 2017). A simultaneously high level of breadth and depth of LTPA, similar to individuals in profile 2, has already been identified by Agans et al. (2017). Furthermore, doing LTPA in self-organised and organised settings (people in profiles 2 and 3) was already shown by Lawler et al. (2017), although profiles 2 and 3 differ regarding the depth of activities. Practicing LTPA in a predominantly self-organised setting (profile 4) has also been shown by other studies (Gut et al., 2020, 2022; Lawler et al., 2017), and conversely, doing LTPA in a predominantly organised setting (profile 6) has similarly been found by other research (Agans and Geldhof, 2012; Borgers et al., 2015; Gut et al., 2020, 2022; Lawler et al., 2017). Our data indicate that focusing on one organisational setting (profiles 4 & 6) was associated with practicing few different LTPAs. Consequently, following the already introduced understanding of human development (Lerner, 2006), the context of behaviour plays an important role for development in youth activities too (Zarrett et al., 2009). The patterns found in this study revealed that practicing LTPA can occur in a variety of

contexts—between and within individuals. This is reflected in our patterns by differing the organisational setting and the breadth of activities as well as the depth of activities.

Relationship between LTPA in youth and lifelong LTPA

Regarding the relationships with lifelong LTPA, the assumption of dependencies over the life course (Bernardi et al., 2019) can be supported by our data. Furthermore, in line with the understanding of human development (e.g. Lerner, 2006), there is not one activity according to LTPA in youth for conducive development (cf. Coakley, 2011) but interindividual differences in LTPA behaviours in youth. Thus, there are different ways to achieve a high level of lifelong LTPA, such as having high values of all indicators (profile 2) or high levels of at least two indicators (profiles 3, 4, & 6). If the *number of regularly active years* and the *number of different activities practiced* was rather low in youth, it is more difficult to achieve many active years in adulthood (profile 5). And mostly inactive people in youth were clearly the least active in adulthood (profile 1). Regarding the well-known social inequalities in practicing LTPA and sports (e.g. Rohrer & Haller, 2015; Scheerder, Vanreusel, Taks, & Renson, 2002), profile 1 displayed a comparatively low educational level and high proportion of women, whereas profile 5 with the second-lowest index of lifelong LTPA did not reflect these social differences. In addition, for example, individuals in profile 4 with the highest activity index over the life course had the second-lowest value regarding educational level and the second-highest proportion of women. Consequently, social inequalities cannot systematically explain the relationship between the LTPA behaviour in youth and lifelong activity.

Considering the differently shaped profiles in youth, it appears that certain indicators can compensate for each other. More specifically, it is evident that a high level of either *number of regularly active years* (> 13) or *number of different activities practiced* (> 4) in youth is crucial to becoming physically active in 80% of the years lived in adulthood (*Index of lifelong LTPA* > 0.80, see profiles 2, 3, 4). Thus, a high value of one of these indicators seems important, but they can compensate for each other. The importance of these two indicators is supported by variable-oriented studies (e.g., correlation or regression analyses) investigating them separately as predictors for lifelong LTPA (Batista et al., 2019; Engström, 2008; Cleland et al., 2012; Kjønniksen et al., 2008), which leads to the conclusion that a high value for both variables in youth is beneficial for lifelong LTPA. Our data also showed that a high value in both variables is beneficial (profile 2), indicating a synergistic effect; however, a compensation mechanism (profiles 3 and 4, and to some extent profile 6) is possible as well. From a theoretical understanding, the importance of the breadth of activities in youth is in line with the early sampling approach (Côté et al., 2007) and the *ability and readiness hypothesis* (Telama, 2009). The relevance of an early start or many physically active years, respectively, in youth is accompanied by time-related dependencies in the life course approach, more precisely the amount of time spent in certain situations or states influences the further course of life (Mayer, 1990), and in the meaning of an early socialisation, early-onset experiences in youth are relevant for shaping lifelong behaviour (Kirk, 2005; Sawyer et al., 2012). Furthermore, regarding organisational settings, being physically active in both settings (organised and self-organised) seems promising regarding lifelong LTPA (see profile 2 and 3), whereas practicing it in a predominantly self-organised setting goes hand-in-hand with a high activity index in adulthood as well (profile 4). However, being physically active only in an organised setting in youth reduced the likelihood to become comparatively very active during adulthood (see profile 6). A possible explanation could be that in adulthood, a more self-organised setting is preferred (Eime et al., 2015, 2020), and thus the organisational change from an only organised setting in youth to a rather self-organised setting in adulthood is accompanied by less activity. The most frequently practiced activities in profile 6 are sports games, predominantly practiced in a club, and maybe such activities are more difficult to continue in a rather self-organised setting in adulthood (cf. Downward, Lera-Lopez, & Rasciute, 2014). This could be an explanation for why the *low diversely active, self-organised early starters* (profile 4) are slightly more active during adulthood. In addition, the *carry-over value hypothesis* (Telama, 2009) may explain the relationship between practicing in a self-organised context in youth and the high level of LTPA during adulthood insofar as so-called lifetime activities (e.g. skiing, swimming or cycling; see categories walking and endurance activities and outdoor- and mountain activities in Supplementary Table 4) were practiced in this setting and can easily be continued during adulthood (see profile 4, but also profiles 2 and 3).

Overall, it should be noted that the differences regarding LTPA during adulthood between profiles 2 to 6 were low. However, when looking at the differences between the profiles 2 to 6 and profile 1, the differences were higher with medium effect sizes. Consequently, to stay active in adulthood any kind of regular LTPA in youth is better, respectively linked to a higher probability, than none. Yet, some profiles are particularly promising in order to reach a mainly continuous LTPA throughout adulthood.

Limitations and future research

Some limitations must be considered for this study. LTPA was measured by self-report and retrospectively. Considering this method is not the most valid with a tendency to overestimate physical activity (Ainsworth & Levy, 2004), efforts were made to gather the most reliable and valid data possible (e.g. reliability test, see Lenze et al., 2021 for further information). Likewise, the frequency and intensity of LTPA were not captured due to the inaccuracy of measuring them in retrospective studies (Ropponen, Levälahti, Simonen, Videman, & Battié, 2001); rather, the regular practice of LTPA in terms of years was captured. Related to this, we are aware that older adults are more prone to a pos-

sible recall bias. However, our reliability test including older adults revealed good reliability values (see Supplementary Table 1). In addition, the activity level of the sample regarding LTPA was slightly higher than for the population in Switzerland (see Lamprecht et al., 2020), but a broad range of the Swiss population was covered with the aim of describing associations in general while not drawing conclusions about the entire population. Moreover, the sample of this study contained a broad age range, meaning that not all participants have already experienced the same life stages. To counteract this, the age of the participants was controlled for the analysis with lifelong LTPA, but not for the profile analysis. However, associated to this, a time-historical effect for the broad age range in this sample cannot be ruled out. Further sociodemographic variables such as sex and educational level were not directly controlled for but showed no systematic effect regarding the relationship to lifelong LTPA, as previously mentioned. Furthermore, the indicators used for the profile analyses were carefully deduced theoretically and empirically and comprise a broad spectrum of LTPA behaviours in relation to time- and context-related aspects over the first 20 years of life from a mainly sociological perspective, but they reflect not detailed and highly differentiated LTPA behaviours, such as specific organised settings of LTPA (e.g. sport club, fitness centre) or psychological aspects of LTPA (e.g. motivation, see Schmid, Gut, Yanagida, & Conzelmann, 2020). Lastly, our data reflect the sport system and culture over several decades in Switzerland, and therefore caution is required for a generalisation to other countries.

These limitations must be considered for implications, and consequently, future research should examine the results found with prospective data, other aspects of LTPA behaviour and in other countries to determine whether similar patterns and relationships to LTPA over the life course would emerge and to better understand the interdependencies over the life course.

Conclusion

In terms of LTPA, being mostly inactive in youth was associated with low lifelong activity, whereas various profiles of LTPA in youth were related to a high or very high activity index over the life course. Thus, there is not just one way for lifelong activity. Considering interacting time- and context-related factors within persons and interindividual differences, multiple constellations in youth were associated with a very high activity index throughout life: a high value for each indicator; either a high depth or breadth of activities, combined with multiple organisational settings or particularly with a self-organised, and somewhat less with an organised setting. Thus, the findings of this study prove beneficial for the promotion of LTPA in youth and consequently over the entire life course.

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Declarations

Conflict of interest. L. Lenze, C. Klostermann, J. Schmid, M. Lamprecht and S. Nagel declare that they have no competing interests.

All studies mentioned were in accordance with the ethical standards and a consent statement was provided in each case.

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Appendix C: Manuscript 3

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Article

Taking Up and Terminating Leisure-Time Physical Activity over the Life Course: The Role of Life Events in the Familial and Occupational Life Domains

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Abstract: Leisure-time physical activity (LTPA) is associated with various health-promoting effects. However, little is known about the relationship between life events and changes in LTPA over the life course, especially when multiple life events occur simultaneously. Therefore, this study examines taking up and terminating LTPA associated with life events in the familial and occupational life domains over 16 years of 16–76-year-old Swiss inhabitants (n = 1857) in a retrospective longitudinal cohort design, using a validated telephone survey and multilevel discrete-time event-history analyses. The results show that taking up LTPA was more likely when ending a relationship and retiring and less likely when becoming a parent; terminating LTPA was more likely when ending a job, starting vocational training after 30 years, a relationship ended for men, and becoming a mother with increasing age. If experiencing multiple life events simultaneously, the greater the number of life events, the more likely persons aged 45–70 years were to take up LTPA and, conversely, the more likely persons aged 15–44 years to terminate LTPA. The relationship between life events and changes in LTPA over the life course was often age dependent, especially when experiencing multiple life events simultaneously. The findings should be considered when promoting LTPA.

Keywords: leisure-time physical activity; life events; life course; multilevel discrete-time event-history analysis; family

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1. Introduction

Regular leisure-time physical activity (LTPA) is a well-known behavior for health promotion [1,2], including in the long term [3]. Considering the high health costs caused by physical inactivity [4], regular and long-term LTPA is desirable from health and economic perspectives. However, research indicates that LTPA has low stability over the life course [5–7]. Changing life circumstances are one reason for changes in LTPA [8] and can be triggered by life events (e.g., birth of a child), which have been shown to have an effect on LTPA [9,10]. Examining life events should aid us in gaining a better understanding of the (in)stability of LTPA over the life course [11].

A significant amount of research on the relationship between certain life events and changes in different forms of physical activity has been conducted with various research designs. Typical life events investigated are changes in relationships [9,10,12], becoming a parent [9,10,12,13], changes in vocational training and occupation [9,10,14], and retirement [10,15]. These studies typically focus on only one or few of these life events separately. These life events are then associated with general physical activity or specific types thereof, such as LTPA. This information is collected via self-report or, in rare cases, objectively for general PA. Prospective and retrospective designs are used for this purpose. Life events and changes in physical activity have been studied with a focus on a single age group,

from adolescents to the elderly, but especially in the context of young adulthood. The study period ranges from a few months to beyond 30 years in rare cases, with an average of about 5 years. In summary, three research gaps have been noted. First, mainly declines in or termination of LTPA have been studied rather than taking up LTPA (again). Second, often, the period of investigation focuses only on a few years in a single age group, meaning that different effects of the same life event on LTPA in relation to age or life stage have not been explored ("timing" of events [5,16]). Third, solely separate life events have been considered.

Here, we used a life-course approach and examined taking up and terminating LTPA associated with different and multiple life events in the familial and occupational life domains over 16 years for Swiss inhabitants (n = 1857; 16–76 years) in a retrospective longitudinal cohort design. Consequently, the picture of the relationship between life events and changes in LTPA can be supplemented in three ways. First, transitions for the exit and entry of LTPA were examined. Second, different age groups were considered over a long period (which illustrated the possible age-dependent effects of life events on LTPA). Third, in addition to specific life events, the effect of simultaneously occurring life events on LTPA was analyzed.

Our study is based on the life-course approach and its basic assumptions considering a long-term view of time and multiple life domains [17]. More specifically, the recently published "life course cube" [17], with its three axes of "time", "level" (inner-individual, individual action, and supra-individual), and "life domain" provided the theoretical framework. Interdependencies and interactions within and across axes represent the life course, but it is not possible to test all interdependencies simultaneously [17,18]. We focused on the individual action in terms of the axis "level" and on the life domain of leisure as well as the familial and occupational life domains when regarding the axis "life domain". Here, the axis "time" was understood as lifetime, whereby earlier experiences and the timing of events in the life course can be decisive for its consequences [19].

Looking first at the life domain of leisure, LTPA is seen as a health-enhancing behavior [20] and was understood here as alternations between episodes of activity and inactivity in the life course [21], which include exercise, sport, and unstructured recreation [22] (see Appendix A for further information). According to the life course cube, LTPA is dependent upon previous experiences therein (axis "time"), and LTPA can be influenced by life events in other life domains, which is also known as the "spillover effect" [23]. Such life events can be described as life experiences that influence the individual's daily routine [24] and disrupt the person–environment fit that has been accustomed over time [25]. Two life domains in which life events occur with large disruptive potential for LTPA are the familial and occupational life domains [10]. After experiencing such life events, for instance, becoming a parent, adaptations are necessary [24,25], which can affect life in general [25] or other life domains [23]. For these adaptation processes, individual resources are necessary [23,26]. Here, life domains compete for resources (e.g., spending time for childcare vs. spending time for LTPA), life domains support or complement each other (e.g., gaining mental-health resources in LTPA for better performance at work), or life domains compensate respectively substitute each other's resources (e.g., missing social exchange at work can be compensated by playing football with friends as an LTPA) [17,27,28]. As shown in these examples, individual resources seem pivotal when looking at life events and LTPA [29]. Furthermore, for physical activity, it has been stated that resources may be shifted away from physical activity after experiencing a life event [30].

With regard to the familial life domain, starting and ending a relationship as well as becoming a parent are relevant life events for LTPA [9,12]. Research has indicated a general negative relationship between becoming a parent and physical activity [13], with a higher decrease in LTPA for women [10]. Consequently, Hypothesis H1 can be formulated on this basis:

Hypothesis H1. *Becoming a parent is positively associated with terminating LTPA—with a larger effect for women.*

Looking at changes in relationships, starting a relationship yields mixed effects on LTPA [10,31] ([31] only in Germany), whereas ending a relationship is related to an increase in LTPA, depending on sex [10]. Overall, current research suggests mixed and rather unclear effects of changes in relationships on LTPA. Due to the inconclusive state of research, the following research question (RQ) is asked: "To what extent are changes in relationships associated with taking up (RQ 1a) or terminating LTPA (RQ 1b)?". In addition, the timing of life events is crucial for LTPA [5,16] but has not been investigated. For example, becoming a parent at the age of 15, 35, or 50 years has different consequences on a person's life.

Within the occupational life domain, education-related and employment-related life events can affect LTPA [10]. Leaving high school (which is often combined with entering university) is associated with a decrease in physical activity [10,14], whereas leaving university is related to no change in physical activity [14]. Starting a new job is related to a decrease in physical activity in young adulthood [10,14], but changes in jobs have revealed inconclusive results for physical activity [10]. On the basis of the different relations of changes in jobs and vocational training on LTPA, the following research question arises: "To what extent are changes in jobs and vocational training associated with taking up (RQ 2a) or terminating LTPA (RQ 2b)?". Retirement is clearly positively related with an increase in LTPA [15]; therefore, we can formulate the following:

Hypothesis H2. *Retirement is positively associated with taking up LTPA.*

Several simultaneously occurring life events trigger greater adaptation processes and, consequently, redistribution of more resources. Only one study has investigated this issue and showed a more negative effect on physical activity in the occurrence of multiple life events in a prospective randomized control trial over two years in the United States [32]. As there is only one study on this topic to date, a research question rather than a hypothesis is stated: "To what extent is the number of simultaneously occurring life events associated with taking up (RQ 3a) or terminating LTPA (RQ 3b)?".

2. Materials and Methods

The retrospective longitudinal study "Physical Activity During Life Course" is funded by the Swiss National Science Foundation and is part of the nationwide state survey "Sport Schweiz 2020" [33]. The study received approval from the Ethics Committee of the School of Education of the University of Applied Sciences and Arts Northwestern Switzerland (Windisch, Switzerland).

2.1. Sample

The sample consists of 1857 Swiss inhabitants aged 16–76 years. They were interviewed once via a telephone survey using the computer-assisted telephone interviewing (CATI) method in 2019. The random sample was recruited via the Federal Statistical Office (n = 753) and with persons from the panel of the survey institute (n = 1104). The mean age (M_{age}) was 55.3 ± 19.09 years, and n = 1119 of the study cohort (60.3%) were women (see Table 1 for more information).

Table 1. Descriptive data for the entire sample n = 1857 persons over 16 years (total n = 27,238 person-years).

Variable	Number of Events	% of Persons in the Sample	
Dependent variables			
Taking up LTPA	514	24%	
Terminating LTPA	260	12.1%	
Independent variables			
Familial life domain			
Starting a relationship (12–72 years)	339	16%	
Ending a relationship (12–72 years)	281	14%	
Becoming a parent (15–54 years)	418	13.8%	
Occupational life domain			
Starting vocational training (15–44 years)	355	21.2%	
Starting a job (15–70 years)	1324	42.9%	
Ending a job (15–70 years)	1537	40.2%	
Retirement (50–72 years)	552	29.7%	
Simultaneously occurring life events (15–70 years)			
1	2623	73%	
2	913	32.5%	
3+	165	7.2%	
Variable	***n* (%)**	**Mean**	***SD***
Control variables			
Time invariant: Sex			
Male (0)	738 (39.7%)		
Female (1)	1119 (60.3%)		
Time invariant: Level of education (1–5)			
Compulsory school (1)	183 (9.9%)		
Secondary school/lower professional education (2)	758 (40.8%)		
Higher professional education leaving certificate (3)	329 (17.7%)		
Technical college (4)	302 (16.3%)		
University (5)	285 (15.3%)		
Time varying: Previous (in)activity duration (1–15) [1]			
Previous activity duration	24,209	13.12	3.92
Previous inactivity duration	3029	9.33	5.81
Time varying: Quotient active years [1]	27,238	0.64	0.21
Time varying: Age group [1]			
until 29 (ref.)	4311 (15.83%)		
30–44	4939 (18.13%		
45–59	10,903 (40.03%)		
60–76	7085 (26.01%)		
Additional information about the sample			
Always physically active (over 16 years)	1338 (72.1%)		
Always physically inactive (over 16 years)	63 (3.4%)		
At the time of the survey physically active	1741 (93.8%)		

Note: SD = standard deviation. [1] Values in person-year due to time-varying control variables.

2.2. Instrument and Operationalization

The questionnaire was a further development of previous studies investigating LTPA during the life course [34]. Throughout the questionnaire, different aspects of current and past regular LTPA over the life course, as well as life events over the past 16 years, were asked retrospectively. The term "regular" refers to at least once a week. The unit for time was years. Hence, for each year of one's life, the binary information of being physically active in leisure or not being physically active in leisure, taking up LTPA or terminating LTPA, respectively, was gathered. Thus, episodes of activity and inactivity were built.

With regard to measuring life events, information on familial and occupational life domains was gathered separately. Life events of 16 years (2004 to 2019) were recorded. From the familial life domain, three life events were captured: (1) starting a relationship, (2) ending a relationship, and (3) becoming a parent. In the occupational life domain, four life

events were included: (1) starting vocational training (with a state-recognized certificate), (2) starting a job, (3) ending a job (excluding retirement), and (4) retirement.

2.3. Data Collection

A memory bias is a problem when measuring retrospective data. Four approaches were taken when attempting to keep this recall error as small as possible and gather reliable data. First, multiple cues and pathways were used to support autobiographical memory, such as hierarchical and sequential pathways [35,36]. The adapted questionnaire was tested and refined in an iterative process in a theoretical (autobiographical memory) and practical manner. For example, qualitative interviews (n = 9) using techniques such as the "think-aloud" method, confidence rating, and behavior coding were carried out [37]. Second, a separate study with the test–retest method was conducted to check the reliability of the final questionnaire. Therefore, n = 29 persons (17 (59%) women and 12 (41%) men) ranging from 23 years to 75 years of age (M_{age} = 51.41 $\pm$ 19.09) were interviewed twice with the final questionnaire 95.07 $\pm$ 15.34 days apart on average.

Considering different scale levels in the questionnaire, Krippendorff's alpha [38] was used for analyses. The recommended convention for a reliable agreement of the data of $\alpha \geq 0.80$ [39] was fulfilled for all variables used (Supplementary Table S1). This criterion is in accordance with findings from similar investigations on reliability [34,40]. Third, the CATI method was chosen to enable trained interviewers to help specifically with problems regarding memory and comprehension. Trained interviewers participating later in the main study conducted 20 interviews to test the technical and content-related functioning of the questionnaire. Fourth, after the data collection was complete, the data were checked carefully for internal inconsistencies and discrepancies. In doing so, 168 persons were excluded. Consequently, from the initial 2025 interviewed persons, n = 1857 were used for analyses. All these efforts at the level of the questionnaire, the interview process, and in data cleaning were made to collect as reliable and valid data as possible.

2.4. Data Analyses

We obtained data from each year from 2004 to 2019 of all 1857 participants. Hence, a person-year file with n = 27,238 data was built. To calculate relationships between life events and taking up LTPA or terminating LTPA, a multilevel discrete-time event history analysis [41] was used. This multilevel type of event history analysis (which can also be called "survival analysis") is equally a generalized linear mixed model (GLMM) and adjusts for the dependency in the person-year file. Hence, multiple measurements over time from the same person are not independent [42]. As usual for event history analysis, a specific "risk set" was made for each calculation [43]. Therefore, separate calculations for each life event linked with taking up or terminating LTPA were carried out. Consequently, only persons who were physically active in the respective year were "at risk" of terminating LTPA and, thus, were part of this risk set. The same approach applied inversely to physically inactive persons and taking up LTPA, as well as for life events (e.g., persons in a relationship are not at risk of starting a new relationship). Episodes of being physically active until becoming inactive could occur more than once in the 16 years recorded and vice versa (e.g., physically active in year 1–3, inactive in year 4–13, and again active in year 14–16). Thus, this was an event history analysis with possible recurrent or repeated events [41,43].

In total, five control variables that could affect LTPA in the life course were derived from the literature and included for each calculation as time-invariant or time-varying variables. The first was sex (time invariant). There are differences in the trajectory of LTPA between men and women in Switzerland [33] and so they were controlled for. The second control variable was level of education (time invariant). Persons with a lower level of education are less physically active then their higher educated counterparts [33]. Therefore, a five-point scale of the level of education analogous to that described by Lamprecht and colleagues [33] was used (Table 1). The third control variable was previous (in)activity

duration (time varying). For each physically active episode or inactive episode, it was indicated (per year) how long this period had lasted already. Only the last 16 years were analyzed, but the data on LTPA over the entire life course were available. Therefore, the duration of the episode was already indicated before year 2004. This knowledge also helps to avoid the statistical problem of left-truncation or delayed entry [41], and the duration of staying in a particular episode is supposed to reduce the risk of change [21]. Due to the different ages of persons in the cohort, the maximal value of this variable was set to 15. The fourth control variable was quotient active years (time varying). In addition to taking into account the duration of the current episode, the number of physically active years in the life course can also affect LTPA [44]. For this purpose, the quotient of the respective physically active years and age was created to consider it. The fifth control variable was age group (time varying). LTPA also differs according to age [33]. Age did not have a linear effect for our study. Hence, age groups were formed based on the method of Wernli and Zella [45]: "1" (under 30 years of age); "2" (30–44 years); "3" (45–59 years); and "4" (60–76 years). To actively include the moderating effect of age and sex on a life event, interactions were calculated and reference categories were switched post hoc for precise statements on specific values [46].

Calculations were undertaken in R (R Foundation for Statistical Computing, Vienna, Austria) [47] with the package "lme4" [48]. The "glmer" command was used for this type of analysis [49] and if convergence issues occurred, the "bglmer" command from the package "blme" was referred to [50]. Thus, maximum likelihood estimations via numerical integration were suggested [41,51]. More precisely, the integral in GLMMs must be approximated and cannot be defined exactly. Therefore, the most reliable approximation is adaptive Gauss–Hermite–Quadrature [48], which was used here. When calculating models, variables were added stepwise and compared with the likelihood ratio test (chi-square test; $p < 0.05$) to identify the model with the best fit for the respective data [51], and the best-fitting model was reported.

3. Results

3.1. Descriptive Analyses

Taking up LTPA and especially terminating LTPA over 16 years did not occur very often ($n_{\text{taking up LTPA}} = 514$ (24% of the sample); $n_{\text{terminating LTPA}} = 260$ (12.1% of the sample)) (Table 1). This was underlined by the observation that 75.5% of the sample remained physically active (72.1%) and inactive (3.4%) for 16 years, in addition to the relatively long previous (in)activity duration, whereby these values were summed from the entire life course. The number of years of the previous activity duration ($n = 24{,}209$; mean = 13.12, SD = 3.92) compared with the number of years of previous inactivity duration ($n = 3029$; mean = 9.33, SD = 5.81) showed that activity episodes occurred more often and persisted for longer. The quotient active years were indicated along the same lines (mean = 0.64, SD = 0.21). When life events were regarded, a higher number of occupational life events was obvious, and there was a notably high number of job changes. Conversely, familial life events did not occur quite as often.

When looking at simultaneously occurring life events, it was observed that two life events in the same year occurred occasionally, but $\geq$3 life events were very rare. Considering the age group, we noted that more than three-quarters of the participants investigated were >45 years of age, which probably explained the frequency of certain life events to some extent. The level of education of this sample showed a slightly right-skewed distribution, but $\geq$15% of the study cohort was represented in the higher education level categories of 3 to 5.

3.2. Relationship between Life Events and Taking Up LTPA in the Life Course

Due to the physically active sample, the risk set for this calculation was rather small. All results presented below can be found in Table 2 (and all full models in Supplementary Tables S2–S9). Beginning with life events in the familial life domain, starting a relationship

carried no association with taking up LTPA (logit = 0.64, $p = 0.21$). However, ending a relationship was positively related with taking up LTPA (logit = 1.31, $p = 0.003$). Thus, if a relationship broke up, the probability of taking up LTPA was significantly higher. Differences for sex or age group were not found (see RQ 1a). For becoming a parent, a reversed effect was detected: if this life event occurred, the probability was significantly lower for taking up LTPA (logit = −1.06, $p = 0.02$), which indirectly supports Hypothesis H1. Furthermore, differences between sexes or age groups did not emerge.

Table 2. Multilevel discrete-time event history analysis with separate calculations for each life event and taking up leisure-time physical activity, controlled for sex, level of education, previous inactivity duration, quotient active years, and age group (for each complete model reported, see Supplementary Materials).

Life Event	Taking Up LTPA			
	n	**Logit**	***SE***	***P***
Familial life domain				
Starting a relationship (12–72 years) [1,2]	804	0.64	0.51	0.21
Ending a relationship (12–72 years) [1]	1586	1.31	0.44	0.003 *
Becoming a parent (15–54 years) [1]	1391	−1.06	0.45	0.02 *
Occupational life domain				
Starting vocational training (15–44 years) [1,2]	759	−0.05	0.46	0.91
Starting a job (15–70 years) [1,2]	2025	0.12	0.25	0.63
Ending a job (15–70 years) [1,2]	1995	0.17	0.27	0.54
Retirement (50–72 years) [1]	935	1.49	0.44	<0.001 *
Simultaneously occurring life events (15–70 years)				
Simul. occurring life events × age group (ref. = 1; <30 y)	2149	−0.15	0.19	0.43
age group 2 (30–44 y)		0.21	0.26	0.42
age group 3 (45–59 y)		0.67	0.29	0.02 *
age group 4 (60–70 y)		1.20	0.42	0.004 *

Note: SD = SE = standard error; * $p < 0.05$. [1] No significant age group differences or sex differences were found. [2] Model with just control variables and without life event fits best, but to show the non-significant effect of life event, this model is presented.

Job changes and starting vocational training as life events did not seem to be closely related with taking up LTPA (RQ 2a). Significant associations did not occur between taking up LTPA and starting vocational training (logit = 0.36, $p = 0.17$) or for starting a job (logit = 0.12, $p = 0.63$), and ending a job (logit = 0.17, $p = 0.54$), but retirement yielded a strong, positive effect on taking up LTPA (logit = 1.49, $p < 0.001$). Hence, persons of either sex who retired had a higher probability to take up LTPA. Thus, Hypothesis H2 was confirmed.

With regard to the number of simultaneously occurring life events (see RQ 3a), the model with age-group differences explained the data best. Considering the interpretation of results when interaction effects were modeled, persons aged 45–59 years (logit = 0.67, $p = 0.02$) and 60–70 years (logit = 1.20, $p = 0.004$) differed significantly from persons under 30 years of age (reference category; logit = –0.15, $p = 0.43$). To not only obtain the differences between age groups but to also compare people in an age group who had experienced life events with people of the same age group who had experienced no or fewer life events, the age group of interest was set as the reference category post hoc (not shown in Table 2, see Supplementary Table S9). Significant effects emerged for persons aged 45–59 years (logit = 0.52, $p = 0.02$) and 60–70 years (logit = 1.01, $p = 0.004$) but not for persons under 30 years of age (reference category in Table 2) and persons aged 30–44 years (logit = 0.06, $p = 0.74$). In summary, for persons between 45 years and 70 years of age, the number of simultaneously occurring life events was associated with a higher probability for taking up LTPA: the more life events, the higher the probability.

3.3. Relationship between Life Events and Terminating LTPA in the Life Course

For terminating LTPA, the risk set was much larger, and more person-years could be included in the calculation due to the physically active sample. All of these results are presented in Table 3 (and all full models in Supplementary Tables S10–S17). Looking at life events in the familial life domain, starting a relationship had no association with terminating LTPA (logit = 0.64, $p = 0.16$), but ending a relationship was linked to terminating LTPA (logit = 1.71, $p = 0.003$) and a significant interaction effect for sex was documented (logit = –2.52, $p = 0.03$) (see RQ 1b). The aforementioned main effect for ending a relationship showed the value for men who ended a relationship compared with men who stayed in a relationship, and it indicated a positive association with terminating LTPA, so men who ended a relationship were more likely to terminate LTPA. When the reference category was changed post hoc, a significant effect for women who ended a relationship did not emerge compared with women who stayed in a relationship for terminating LTPA (logit = –0.82, $p = 0.43$) (Supplementary Table S11).

Table 3. Multilevel discrete-time event history analysis with separate calculations for each life event and terminating leisure-time physical activity, controlled for sex, level of education, previous activity duration, quotient active years, and age group (for each complete model, see Supplementary Materials).

Life Event	Terminating LTPA			
	n	**Logit**	***SE***	***P***
Familial life domain				
Starting a relationship (12–72 years) [1,2]	5427	0.64	0.46	0.16
Ending a relationship (12–72 years)				
Ending a relationship × sex (ref. = men)	17,741	1.71	0.57	0.003 *
sex (women)		–2.52	1.17	0.03 *
Becoming a parent (15–54 years) [3]				
Becoming a parent × age group (ref. = 1; <30 y) × sex (ref. = men)	12,689	−1.89	1.25	0.13
age group 2 (30–44 y)		1.57	0.72	0.03 *
age group 3 (45–54 y)		2.50	1.34	0.06
sex (women)		3.15	1.09	0.004 *
Occupational life domain				
Starting vocational training (15–44 years)				
Starting voc. training × age group (ref. = 1; <30 y)	5385	0.17	0.43	0.68
age group 2 (30–44 y)		1.90	0.66	0.004 *
Starting a job (15–70 years) [1,2]	19,690	0.02	0.26	0.93
Ending a job (15–70 years) [1]	19,355	0.82	0.22	<0.001 *
Retirement (50–72 years) [1]	10,653	–0.36	0.74	0.62
Simultaneously occurring life events (15–70 years)				
Simul. occurring life events × age group (ref. = 1; <30 y)	21,783	0.30	0.15	0.04 *
age group 2 (30–44 y)		0.53	0.21	0.01 *
age group 3 (45–59 y)		–0.13	0.28	0.63
age group 4 (60–70 y)		0.09	0.47	0.84

Note: SD = SE = standard error; * $p < 0.05$. [1] No significant age group differences or sex differences were found. [2] Model with just control variables and without life event fits best, but to show the non-significant effect of life event, this model is presented. [3] The model with two 2-way interactions (becoming a parent × age group and Becoming a parent × sex) fits best and is therefore presented.

For becoming a parent, the model with two interactions (becoming a parent × sex, and becoming a parent × age group) fitted the data best. For interpretation of these results, the values of the changed reference categories from Supplementary Table S12 should be consulted directly. For men who became a parent, compared with men who do not attain fatherhood, no significant effects for terminating LTPA were detected for all age groups (<30 years: logit = −1.89, $p = 0.13$; 30–44 years: logit = –0.31, $p = 0.77$; 45–54 years:

logit = 0.66, $p = 0.65$) (Supplementary Table S12). For women, the opposite was true. Almost in the entire life course, significant effects occurred for terminating LTPA when becoming a mother, compared with women who did not attain motherhood, with increasing effects with age (<30 years: logit = 1.26, $p = 0.06$; 30–44 years: logit = 2.84, $p < 0.001$; 45–54 years: logit = 3.76, $p = 0.002$) (Supplementary Table S12). In summary, the later in life one becomes a parent, the more likely women were to terminate LTPA, whereas men were not affected. Thus, Hypothesis H1 could be partially confirmed: for women, but not for men.

With regard to life events in the occupational life domain, the relationship between starting vocational training and terminating LTPA was dependent upon age (see RQ 2b). While there was no effect for people aged 15–29 years (logit = 0.17, $p = 0.68$), persons aged 30–44 years differed significantly (logit = 1.90, $p = 0.004$) and post hoc results from a changed reference category showed a higher probability for terminating LTPA within this age range (logit = 2.07, $p < 0.001$) (Supplementary Table S13). Starting a job did not seem to affect termination of LTPA (logit = 0.02, $p = 0.93$), whereas ending a job was positively associated with terminating LTPA in general (logit = 0.82, $p < 0.001$) with no sex or age group differences (see RQ 2b). The final ending of a job (retirement) was not related to termination of LTPA (logit = –0.36, $p = 0.62$).

If multiple life events occurred simultaneously, significant differences between age groups emerged (see RQ 3b). Post hoc results from the changed reference categories (Supplementary Table S17) yielded significant effects for terminating LTPA upon experiencing multiple life events for persons aged 15–29 years (logit = 0.30, $p = 0.04$) and even more for those aged 30–44 years (logit = 0.83, $p = 0.01$). If older than 44 years, multiple life events did not affect termination of LTPA (45–59 years: logit = 0.16, $p = 0.48$; 60–72 years: logit = 0.40, $p = 0.38$).

4. Discussion

In this study, transitions into and out of LTPA in the life course were investigated when experiencing single and multiple life events in the familial and occupational life domains. Using retrospective longitudinal data over 16 years from persons aged 16–76 years, each age in the life course was covered. In addition to the known effects of single life events on LTPA in "common" age ranges [10], age differences and the occurrence of multiple simultaneous life events were investigated for the first time. Overall, life events were more closely associated with terminating LTPA than with taking up LTPA. However, these data should not be viewed only negatively, as they can also be seen as an opportunity at certain life stages. Thus, the timing of events [5,16,19] is crucial for certain life events. Furthermore, the interdependencies between life domains were therefore partially evident and could be an indication that the occurrence of (multiple) life events competed with the resources between the respective life domains. However, they could also be interrelated in a supportive, complementary, and compensatory way [17,27,28].

This results provide new insights into how life events are related with LTPA over the life course and are partly in accordance with data from previous studies. A summary of the results is shown in Table 4. From the familial life domain, starting a relationship did not have an association with transitions in LTPA in the life course (see RQ 1) and, thus, showed neither positive nor negative effects [10]. In contrast, ending a relationship in the life course increased the likelihood of taking up LTPA, but there was also a higher probability of terminating LTPA for men. Hence, women tended to have or invested more resources for LTPA after a break-up (perhaps in the sense of a compensation effect), whereas men seemed to have a change in their resources that could lead to taking up or terminating LTPA.

Table 4. Summary of results for the relationship between life events and taking up or terminating LTPA.

Life Event	Taking Up LTPA	Terminating LTPA
Familial life domain		
Starting a relationship (12–72 years; RQ 1)	*No relationship*	*No relationship*
Ending a relationship (12–72 years; RQ 1)	↑	↑ For men
Becoming a parent (15–54 years; H 1)	↓	↑ For women, with an increasing effect with age
Occupational life domain		
Starting a vocational training (15–44 years; RQ 2)	*No relationship*	↑ For 30–44 years old
Starting a job (15–70 years; RQ 2)	*No relationship*	*No relationship*
Ending a job (15–70 years; RQ 2)	*No relationship*	↑
Retirement (50–72 years; H2)	↑	*No relationship*
Simultaneously occurring life events (15–70 years; RQ 3)	↑ For 45–70 years old	↑ For 15–44 years old

Note: ↑ means a significant positive statistical relationship; ↓ means a significant negative statistical relationship.

Becoming a parent is, in general, not conducive to LTPA [13,24], but interesting differences between sexes and age were shown in this study. For both sexes and over the entire life course, taking up LTPA was less likely if you became a parent, but terminating LTPA differed between sexes (see H1) and age groups: Men were not affected, while for women of increasing age, an even higher risk for terminating LTPA was documented. These observations could be explained by the additional resources needed for mothers than for fathers (life domains compete for resources). In addition, the later the birth in the life course, the more the person–environment fit that had been accustomed over time could be disrupted, and adjustment seemed to be more difficult [25].

With regard to life events in the occupational life domain (see RQ 2), starting vocational training did not yield the suggested negative effect regarding LTPA in youth and early adulthood [10,14]. This finding may have been due to a different education system in Switzerland or due to compensating or supporting resources between the life domains (e.g., recovery from educational stress by using LTPA). However, we did not examine specific vocational training (e.g., entering university) but instead general vocational training with a state-recognized certificate, and only vocational training from the age of 15 years was included (where transition to secondary schools takes place in Switzerland). Nevertheless, starting vocational training at 15–29 years of age was not related to terminating or taking up LTPA. Surprisingly, starting vocational training after 29 years of age was associated with terminating LTPA. The timing of life events is crucial, as demonstrated here by the start of vocational training in a rather "uncommon" phase of life. One possible reason could be competing resources between the life domains (e.g., the resource time due to already consolidated life circumstances). In the present study, when starting a job, the postulated negative effect on LTPA [10,14] was not found for young adulthood (possibly because of a different education system in Switzerland) or for the entire life course. We did not separately investigate the first entry into the labor market, where the largest effects occur [10]. However, starting a job in the life course did not seem to alter individual resources to change LTPA behavior, or it could be explained by compensating or supporting effects (e.g., maintaining a work–life balance due to LTPA). The reported inconclusive effects of ending a job on LTPA [10] suggest in the present study that this life event leads only to a higher probability for terminating LTPA but has no effect on taking up LTPA. It seems that the possibly newly gained resources by ending a job are not used for LTPA or that compensation of occupational strains through LTPA is no longer necessary. However, whether a new job or training was started immediately afterwards was not investigated. The postulated positive effect of retirement on LTPA[31] was shown with the high probability of taking up LTPA upon retirement (see H2). The newly gained resources could explain this association.

Simultaneously occurring life events showed the redistribution of resources in both ways and with age differences (see RQ 3). The more life events experienced at 45–70 years of age, the higher the probability of taking up LTPA, whereas this relationship was not

found for persons aged 15–44 years. Thus, in older adulthood, the "window of change" due to multiple life events was used in a positive way with regard to LTPA. In younger ages (15–44 years), the more life events experienced, the more likely was termination of LTPA, whereas this effect was not present for older persons (45–70 years). Therefore, in this case, the window of opportunity led to a negative change concerning physical activity, as shown by Oman and colleagues but for older adults (>50 years) [32]. Hence, until 44 years of age, multiple life events were related to LTPA termination whereas, after 44 years of age, they were linked to an increased chance of taking up LTPA. The explanation of a larger adjustment when more life events occurs seems plausible, but the direction of the change appears to depend on age, and the reasons for the direction of change are not clear.

The timing of events is interesting because age differences for becoming a parent and starting vocational training on terminating LTPA indicate an effect at mainly non-normative life stages [26] for these life events (becoming a parent until 54 years; starting vocational training at 30–44 years of age). Moreover, timing seems to be the crucial part when considering simultaneously occurring life events and LTPA, with different or even opposite effects depending on age. Differences between sexes occurred only for familial life events. Therefore, these life events seemed to be affected by sex-specific behavior and possibly societal expectancies. Furthermore, besides the investigated moderating effect of sex and age group, the effect of the education level together with life events was tested on LTPA. Tendencies ($p < 0.10$) for just two life events were noted. The already reported relationship between ending a job and terminating LTPA could be "cushioned" by higher education, and the latter decreased the probability of terminating LTPA even more when someone retired. Consequently, a higher level of education could be seen as another type of individual resource for the occupational life domain.

We were able to show novel results by: (i) investigating concurrent taking up and terminating LTPA in the life course, which also uncovered competing effects (e.g., for ending a relationship in men); (ii) differentiating for age groups (i.e., certain life events depend on age when regarding the effect on LTPA); (iii) showing the reasoned effect of simultaneously occurring life events on LTPA with a higher redistribution of resources, which was revealed to be different for the age groups we evaluated.

4.1. Limitations

Some limitations have to be considered for this study. First, LTPA was self-reported and retrospective. Knowing that this is not the most valid method [52], as it often yields an overestimate of physical activity [53], efforts were made to gather the most reliable and valid data possible. To do this, we used a reliability test, although a lack of validity cannot be ruled out. Furthermore, transitions regarding LTPA (terminating or taking up) were investigated but not decreases or increases in LTPA. Therefore, the biggest change was measured, but strong decreases or increases were not captured. In addition, to be considered physically active in this study, the minimum of once per week was used. However, we have no information on intensity and frequency (except at least once a week), which is poorly captured in retrospective studies in general [40]. Therefore, it is not possible to say with certainty whether the physical activity recommendations are met. Moreover, in the physically active sample, the risk set for taking up LTPA was small. This led to relatively low statistical power for calculations with life events and taking up LTPA. Thus, the absence of significant interaction effects could perhaps be attributed to (among others) low statistical power. Additionally, many life changes occur in the first chosen age group up to 29. This age group was not further differentiated, in addition to the reasons given in Section 2.4, due to the age distribution of the sample. As shown in Table 1, this age group is still the smallest. Beyond that, the duration of an active episode or inactive episode after a transition (taking up or terminating LTPA) was not taken into account but was set to $\geq$1 year. Hence, it is not known if, for instance, after terminating LTPA, the subsequent inactive episode lasted just 1 year or 7 years. Moreover, the interrelations between the life domains when regarding resources were not shown and, thus, could not be

uncovered empirically. Lastly, this study covers life events in the familial and occupational life domains, which are highly relevant to this topic [10]. Other relevant life events, such as those that are health related or residence related, are not included here.

4.2. Future Research

New findings have been gained regarding age differences and the number of life events experienced. Consequently, when examining life events and changes in LTPA, age and the possibility of multiple life events occurring simultaneously must be considered for future research. In addition, the general theoretical approach of the life course cube with the spillover effect and related changing resources was applied to LTPA and life events for the first time. Therefore, further research should examine in further depth how this mechanism of the spillover effect with changing resources works in specific constellations (different and combined life events in various life domains and different age groups) in order to derive precise implications and more specific theories. Furthermore, our study should be replicated prospectively and changes integrated in the LTPA level with objective measurement methods.

5. Conclusions

The positive and/or negative associations of life events on taking up or terminating LTPA can occur identically over the life course or be limited to specific life stages, depending on the type and number of life events. Therefore, for inactive persons, supporting programs or interventions can be considered when experiencing (multiple) life events for a positive change regarding LTPA. Opportunities for cushioning the possible adverse effects of life events for LTPA should be developed for active persons. One promising approach (indicated by the results for control variables in the Supplementary Materials) is the (early) promotion of LTPA in general. This is because the more physically active years a person has had in their life, the higher the chance is of taking up LTPA again. Moreover, the longer the previous active episodes lasted, the lower the risk of them terminating LTPA.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/ijerph18189809/s1, Table S1: Values of the Krippendorff's alpha for the test–retest–reliability (n = 29); Table S2: Multilevel discrete–time event–history analysis for starting a relationship on taking up LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S3: Multilevel discrete–time event–history analysis for ending a relationship on taking up LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S4: Multilevel discrete–time event–history analysis for becoming a parent on taking up LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S5: Multilevel discrete–time event–history analysis for starting vocational training on taking up LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S6: Multilevel discrete–time event–history analysis for starting a job on taking up LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S7: Multilevel discrete–time event–history analysis for ending a job on taking up LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S8: Multilevel discrete–time event–history analysis for retirement on taking up LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S9: Multilevel discrete–time event–history analysis for simultaneously occurring life events on taking up LTPA. The model presented due to the best fit is calculated with the interaction effects for simultaneously occurred life events × age group, whereas the interaction with sex does not improve model fit; Table S10: Multilevel discrete–time event–history analysis for starting a relationship on terminating LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S11: Multilevel discrete–time event–history analysis for ending a relationship on terminating LTPA. The model presented due to the best fit is

calculated with the interaction effects for ending a relationship × sex, whereas the interaction with age group does not improve model fit; Table S12: Multilevel discrete–time event–history analysis for becoming a parent on terminating LTPA. The model presented due to the best fit is calculated with the interaction effects for becoming a parent × age group and becoming a parent × sex; Table S13: Multilevel discrete–time event–history analysis for starting vocational training on terminating LTPA. The model presented due to the best fit is calculated with the interaction effects for ending a relationship × age group, whereas the interaction with sex does not improve model fit; Table S14: Multilevel discrete–time event–history analysis for starting a job on terminating LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S15: Multilevel discrete–time event–history analysis for ending a job on terminating LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S16: Multilevel discrete–time event–history analysis for retirement on terminating LTPA. The model presented is calculated without interaction effects for the life event with gender and/or age groups, because this does not improve model fit; Table S17: Multilevel discrete–time event–history analysis for simultaneously occurring life events on terminating LTPA. The model presented due to the best fit is calculated with the interaction effects for simultaneously occurred life events × age group, whereas the interaction with sex does not improve model fit

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Appendix A

The definition of LTPA in this study is based on the subjective, intuitive understanding of sport and physical activity by the study participants, and it refers to Khan et al. [22] who distinguish four types of physical activity: occupational; transport; domestic; and leisure time, which includes exercise, sport, and unstructured recreation. Consequently, e.g., gardening does not count as LTPA in this study, but regularly going for a walk (with your dog, for example) or riding a bicycle during leisure time (and not as a transport activity for the purpose of commuting to work) counts as LTPA. Furthermore, in German, the term "sport" refers not only to organized activities but also informal activities, such as cycling or walking/hiking in leisure (see Willimczik [54]). Thus, in Switzerland, sport is understood as a very broad concept and includes LTPA.

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