bioMAP - Development of a software for the retrospective analysis of biopsychosocial health trajectories in elite sport

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1 Introduction and Objectives

The highly individualized management and control of training processes poses a significant challenge for coaches, particularly in team sports. Existing approaches for the management and control of training processes in elite sports have mostly been medically or technologically oriented. However, only a few instruments are available for specifically recording health trajectories and developmental processes.
Results of the WVL project "Individual Health Management in Young Competitive Sports (GOAL)" (Thiel et al., 2011) suggest that health-related developmental processes as well as the athletes' individual life worlds have a considerable influence on their performance development. The inclusion of these aspects into the training process represents a particular problem for coaches at the elite level, since they interact with their athletes only during a limited amount of time. In combination with the variety of tasks and limited time resources, coaches barely have the opportunity to take the athletes' life circumstances and their development with regard to health and personality into account when managing their training and performance development. The aim of the service project therefore was to develop an analytical instrument that would enable an intra- and inter-individual comparison of biopsychosocial health trajectories of young athletes while taking their lifeworld into account. The objective was to verbally and visually examine the biographical development of biopsychosocial health indicators depicted in a coordinate system by means of different curve courses. The analysis tool should be developed in the form of a software program for a tablet computer, which would allow the recording but also the immediate analysis and interpretation of the data.
As a basis for the software program, we used the biographical mapping approach, which was originally developed in the BISp-funded project "Gesundheit im Spitzensport [Health in elite sport]" (Mayer, 2010; Thiel, Mayer & Digel, 2010) and refined in the GOAL project (Thiel et al., 2011). This method was used very successfully in the GOAL project to monitor growth-related and overload-related disorders in young competitive athletes. The method also showed potential for the monitoring of athletes' health because it is often quite difficult for athletes to verbalize sensitive topics such as painful experiences and stigmatizing conditions due to the elite sports *culture of risk*, which is characterized by the concealment and trivialization of pain and injuries (Schubring & Thiel, 2014). The biographical approach makes it possible to identify health-related crises of athletes in a differentiated manner. These crises often result from complex interrelations between social conditions and critical life events over a longer period of time and mostly follow chaotic structures (Frank, 1995). With regard to the recording of biographically significant health indicators, we were guided by the biopsychosocial health model and its transfer to the field of youth sports (Thiel, Schubring, Schneider, Zipfel & Mayer, 2015).

The following biographical mapping (Fig. 1) from the GOAL project illustrates the chosen approach of visualizing biographically significant developmental processes.

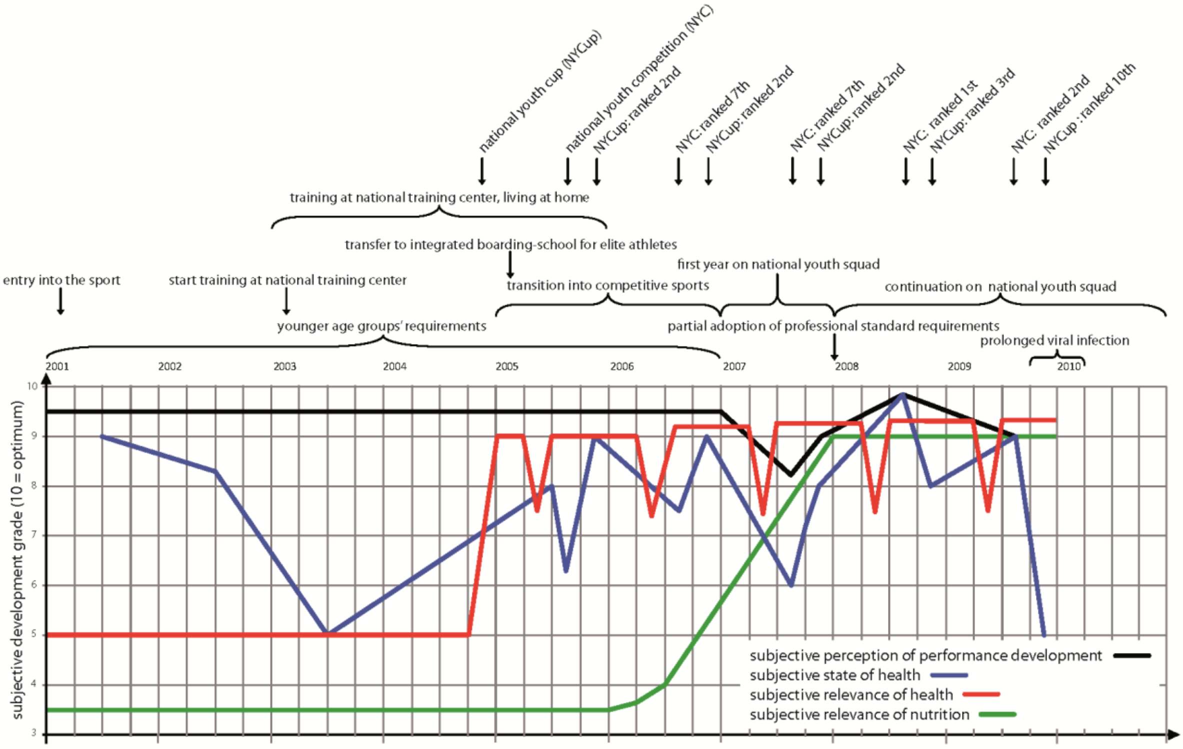

Figure 1: Exemplary biographical mapping (Thiel, Schubring, Schneider, Zipfel & Mayer, 2015)

Until the service project, the procedure had served as a scientific assessment tool but, due to the time and organizational effort involved, it was hardly suitable for transfer into the practice of elite sports. Up to the described service project, the athlete had to draw the curves and context information by hand into a pre-printed coordinate system. Afterwards, all the information had to be digitalized and processed with a graphic program. The development of an appropriate software tool for the simple recording, presentation, and analysis of biopsychosocial health indicators was therefore a central prerequisite for the transfer into the practice of elite sports. The primary goal of the project was to develop a software-based tool for coaches that would enable them to manage and control their training practices based on the athletes' subjective experiences.

For coaches, the development of such a software is of great value because it allows them to familiarize themselves quickly and yet in detail with biographically significant health-related developmental processes of their athletes in order to initiate interventions at an early stage (e.g. training adaptations, involvement of health experts etc.). In this way

- processes of overloading and distress can be recorded at an early stage,
- critical moments can be identified in athletes' biographies, and
- relations between athletic performance and biopsychosocial health indicators can be identified.

This is particularly relevant for coaches of teams with frequently changing players.

Our own preliminary work on the biographical system mapping method (see above) was the basis for the development of the software for the analysis of health-relevant developmental processes. The following basic functions had to be translated into the software for the digital assessment of these biographical trajectories:

In order to generate an individualized time axis, central orientation points of the athlete's biography (e.g. age, nomination for the national team, change of club, change of school, athletic successes etc.) must first be recorded and displayed on the x-axis. Using this individualized coordinate system, the athletes then reconstruct, for example, the course of their subjectively experienced state of health, athletic performance capability, or biographically relevant injury and illness courses. The athletes draw these respective curves into the coordinate system via the touch screen. The y-axis represents an intensity-scale ranging from 0 -10 with larger values representing a more pronounced expression of the respective variable, e.g. of the subjective state of health. The curves are recorded one after the other, and the previously drawn curves do not remain visible in the coordinate system to reduce reciprocal influences. The x-axis remains the same throughout the interview and can be used for orientation purposes, but can be supplemented with other important life events if required. After all curves have been drawn and recorded electronically, it should be possible to compare selected curves with each other for analysis purposes. The software should allow to transfer the data to Excel and thus also to the SPSS statistics program, so that statistical analyses can also be conducted (especially for larger samples or for the analysis of curve courses). The primary goal of the service project therefore was to develop a functional software for the analysis of biographical developmental processes. This software should fulfill the everyday demands of elite sports with regard to design, handling, and content.

2 Documentation of the Project Phases for Software Development

In general, the methodological approach of the service project was based on the central phases and milestones of software development (cf. Grechening, Bernhart, Breiteneder & Kappel, 2010). Beside development workshops with selected experts from elite sports, extensive alpha and beta tests were conducted with coaches and athletes. This ensured that the software design was guided by the specific requirements of elite sports. Thus, aspects of user-friendliness were taken into account in the development of the end product right from the start of the project.

The implementation of the project was divided into the following three phases:

1. Analysis and definition of requirements
2. Conception and development of the alpha and beta version
3. Test, documentation, and implementation of the Release Candidate

These project phases were regularly documented and evaluated as part of the service project and are described in detail below.

2.1 Collaboration Partners

The German Volleyball Association acted as the overarching collaboration partner for the project. The software development was carried out with the Bundesstützpunkt

Nachwuchs Volleyball [German federal youth training base] of the VC Olympia Berlin. As a volleyball club with an affiliated boarding school, which houses the best German volleyball and beach volleyball talents in Berlin and thus pursues a sustainable talent development concept, it was possible to win a collaborator who allowed us to carry out the development of the software in an absolutely elite sports-oriented context. Through already existing good contacts with the manager of the Bundesstützpunkt Nachwuchs [German federal youth training base], Jörg Papenheim, we were able to involve experts (coaches and young athletes) during the development of the software. This made it possible to conduct a detailed field test of the beta version with young German volleyball talents and thus test the usability of the software in practice.

2.2 Project Phase 1 - Analysis and Definition of Requirements

2.2.1 Project Start and Detailed Planning

As a first step, an IT specialist advised us on the technical possibilities and limits of software programming. Additionally, we interviewed Jörg Papenheim (manager of the VCO Berlin) about the initial expectations from sports practice as well as ideas for the content of the curve courses. From this first collection, we derived the following variables:

- Subjective health/subjective complaints (including growth problems)
- Development of burnout
- Compatibility between school and elite sports
- Eating disorder
- Performance development (including aspiration for success)
- Adaptation to the training group (coping with status passages)
- Pressure to perform
- Overtraining
- Recovery (mental/physical)

These very general initial health dimensions were further concretized over the course of the three project phases and implemented into the bioMAP software. In addition to this collection of ideas about potentially relevant health indicators, we developed the following research questions, which guided the design of the content of the software:

- How stressful are the major competitions in a season for the athletes and how stressful is the preparation for those?
- What influences the selection for the starting team and how is this selection process experienced by the athletes themselves?
- How much pressure do athletes experience from competing against others?
- How do athletes react to their coaches?
- How much pressure do coaches put on their athletes?
- Observing the development of an eating disorder (with additional use of the Questionnaire from Paul & Thiel)
    - What role does the coach play in this regard, what role do the parents play (from the subjective perspective of the athlete)?
    - How do the athletes themselves perceive their weight?

Additionally, we identified the following points as limits or difficulties that had to be taken into account during the development the software and the actual interviews and analyses:

- Anonymity
- Social desirability
- Technical difficulties
- Practicability → Required time, spatial conditions

Based on this first collection of ideas, the first expert workshop in Berlin was prepared.

2.2.2 Preparation and Organization of Expert Workshop I

For the first project workshop, we wanted to give a presentation focused on the content of the software. Here, we aimed to focus on the relevance and necessity of the software and present a 'pre-alpha version' to illustrate the basic principles of the biographical mapping approach and demonstrate the difference between a pencil-paper version and a digital one. In close consultation with our programmer, we developed a first 'raw version' of the software, which already included the following basic functions:

- Creation of a personal profile (including basic personal data)
- Entry of biographically relevant events into the coordinate system
- Drawing of health-related curves into the coordinate system
- Selection and comparison of several curves

2.2.3 Implementation and Evaluation of Expert Workshop I

The first expert workshop on September the 15th, 2016 at the German federal youth training base in Berlin had the aim to present the project and to work out the practical requirements for the assessment tool. In order to integrate the expectations of elite sports into the development process right from the start, the workshop was attended by manager Jörg Papenheim and the branch manager, two junior national coaches, one athletic trainer, and three athletes (2 females, 1 male). The content presentation was strongly focused on the background and the advantages of the biographical mapping approach. During the workshop, all workshop participants were asked to draw their own biographical mapping on paper. A rudimentary version of the bioMAP software was also presented to illustrate the advantages of a digital assessment tool.

The practical requirements and expectations from the perspective of elite sports were then developed in small groups (coaches and athletes separated) and then in a discussion with all participants. The discussions were led by the following questions:

1 Which health-related developmental processes are of interest?
2. What are the expectations regarding the usability of the software?
3. What are the difficulties/problems/limitations/open questions regarding the software?

The following results were collected, especially from the perspective of coaches and athletes (see Tab. 1 and 2).

Table 1: Results from the coaches' perspective (Workshop I)

Relevant data on health-related developmental processes	Expectations with regard to usability	Difficulties/limits/open questions
- Well-being in relation to load (objective and subjective) - General curve for physical complaints and injuries (not focused on singular illnesses or injuries) - Pressure from expectations in school (stress in school) - Curves on motivation (sport, school, nutrition → has to be differentiated) - Private life (relationships, living conditions) - Diet (factual and processual knowledge, knowledge and putting it into practice) - Time for recovery - Personality characteristics to support individualists, who want to take responsibility and are willing to risk something	- Software should work on all mobile devices - Fast tracking of curves has to be possible if used in training sessions (max. 10 minutes) - Flexible switching between different input masks should be possible	- Time points of data collection (weekly, monthly, etc.) - How will results be transferred to practice? What new information does the data generate? Background: Coaches are aware of (social) factors, but are unable to influence those because the relevant structures (school load) are outside of their control - Limits of the bioMap are discussed against the background of experiences with an already existing training load monitoring app, that is used directly after the training session. Problem: requires effort, athletes do not really participate, have to be forced, added value does not justify the effort required - Idea of athletes to design the app as a diary for athletes is discussed by the coaches. Athletes could use it independently on their own devices at selected time points. The coaches receive this information regularly. This helps athletes to self-reflect and coaches would get an insight into this (with relatively limited time efforts).

Over the course of the event, we recognized that the term 'app' is associated with a very specific understanding of software among athletes; namely that of a program for use on their own smartphone or tablet, which is 'fed' with data at regular intervals. During the small group discussion, the athletes therefore independently developed the idea of a kind of 'athlete's diary', This idea extended the original idea of developing an assessment tool for coaches.

Table 2: Results from the athletes' perspective (Workshop I)

Relevant data on health-related developmental processes	Expectations with regard to usability	Difficulties/limits/open questions
- Clear distinction between sport and private life. Each area should be assessed with a different curve, also to illustrate the personal relevance of private life and sport. - Curve on stress - Performance pressure (School, vocational training or studies separated from sport) - Performance development (subjectively perceived by athlete him- or herself and 'objectively' perceived by the coach, also with regard to performance at school) - Difficulty of organizing daily life (commuting, boarding school vs. living with parents) - Time effort required for school, training, leisure time (over a whole season to see differences between preparation period, training camps, national team, holidays etc.)	- App has to look modern and appealing otherwise it will not be stimulating - Flexible data collection - Should be possible to compare subjective assessment of athletes with those of their coaches - Should be possible to supplement the subjective data with objective performance measures and to integrate training schedules - Symbols for the single curves (house, heart etc.) - Smileys instead of a numerical scale from 0 to 10 would be more appealing - For use as an athlete's diary: personalization through photo uploads and use on several end devices	- Problem of social desirability should be taken seriously. It is likely that athletes will not share certain information (with regard to stress, private life, relationships, and family) with their coaches - How will data be used? What is the added value? Athletes do not recognize a clear benefit - When and how often will the assessment take place? How long will it take? - Reconstruction over a longer period of time appears to be inaccurate. Athletes suggest a regular assessment through themselves instead of a punctual assessment though the coach. But then it has to be possible to hide certain curves from the coach.

From the athletes' point of view, biographical mappings are also an interesting tool for self-reflection. The data would not necessarily have to be shared with the coach in order to draw one's own conclusions, or could just be used as a basis for a subsequent discussion with the coach.

<u>Summary and conclusion</u>

The need for holistic health-related care and individual training management was recognized and accepted with broad consensus. The instrument itself was also seen as useful, as it can provide important information that is often difficult to access. In addition, the added value of the initiation of self-reflection processes was mentioned, which in particular can provide a basis for discussions between coaches and athletes and also enables athletes to critically examine their own careers.

However, it also became apparent that the direct benefit of the software for coaches and athletes must be made more obvious. Although an added value was noticed, it was viewed rather critically with regard to the time required for conducting a biographical mapping. In particular, the time required for the planned assessment through the coaches was viewed very critically (e.g. quote from a coach: "this should take a maximum of 10 minutes").

The full potential of a reconstruction of biographical processes for the daily training practice was apparently not yet fully recognized. In this regard, coaches and athletes often voiced the concern that the curves would not be exact and that only rough approximations would be possible, especially for longer periods of time (e.g. because one does not remember exactly). The participants therefore repeatedly asked for an accompanying, prospective entry in order to obtain 'more accurate' data. Coaches and athletes agreed that a software, which allows an entry at regular intervals or after significant events, would be useful for athletes. A subset of curves that athletes themselves would collect and select could then be made available to the coaches.

With regard to the developmental curves, the following particularly relevant developmental variables were identified:

- Perception of stress
- Subjective and 'objective'/biological health
- Performance-related variables
- Motivation/fun at volleyball
- Nutrition-related variables

An exact formulation of the labels of the curves proved to be difficult. A central problem was the question of when the software should be used and how it should be implemented.

2.2.4 Process Evaluation Phase I

On the basis of the first development steps and in particular the feedback from the first workshop, the following conclusions were drawn:

- The design should be as modern and appealing as possible so that the program is accepted by the athletes.
- The programming of a prospective 'athlete diary' is not possible within the specifics of this project, but should be pursued in the future.

In addition, based on the evaluation, we developed three application scenarios for the software, which were to be clarified again in the second expert workshop:

1. **Tool for coaches for the initial assessment of new team members** in order to create a general understanding for the individualized training management by identifying individual opportunities for further development and already existing health problems.

2. **Tool for coaches for the systematic optimization of health and performance management.** This could take place once a year before the beginning of a new season within the framework of newly implemented 'talks about development' with athletes. The graphically supported reflection and evaluation of the past season could help to derive health-related and performance-related opportunities for further development, identify long-term health problems at an early stage, and observe overarching problem mechanisms at the team level (e.g. systematic overload).

3. **Scientific instrument** for identifying typical high-stress phases and health-sensitive phases in athletes' biographies in top-level volleyball (accompanying scientific study).

The data generated with the first two practice-oriented application scenarios could also be analyzed in aggregated form for scientific purposes.

2.3 Project Phase 2 - Conception and Development of Alpha and Beta Versions

2.3.1 Development and Programming of an Alpha Version

Based on the feedback from the first workshop and the further specification of the application scenarios, the 'pre-alpha version' was further developed into a first alpha version. Here, we placed a particular focus on the functional design. Through several internal test runs and discussions with our IT specialist, we were able to develop a basic design that allows an intuitive data collection and analysis. In particular, we considered the following points:

- Visual and color arrangement as well as the labeling of the tabs and the coordinate system
- Implementation of the assessment from the start of the software till completion → User-friendly implementation
- Possibilities of data collection with regard to biographical events and curve courses

The process of data collection with the alpha version of the bioMAP software is depicted in Table 3:

Table 3: Process of data collection with the alpha version

1. Start screen: *Open study*
Project → Select an already created project from the folder Message on how many persons were already registered in the project pops up → *Ok*. Afterwards, further tabs are opened in the headline
2. Tab: *Create/edit person*
Select existing person or create a new person → *New* → First name, surname or pseudonym To delete existing person → *Delete*
3. Tab: *GesMAP*
Can only be selected when a person is chosen Enter biographical events → *Enter events* or double click on the time line → Date, type of event (e.g. athletic, school-specific, private) and enter description To assess developmental curves → *Draw curves* → Select curve → Draw → Draw the curve course by hand (on tablet) or with mouse (laptop)
4. Tab: *Analysis*
Select curves that you want to analyze Events are depicted in different colors on the time line (e.g. athletic event = red) Description of events is displayed in a pop-up window
5. Tab: *Options*
Selected curve courses can be *exported as an image* Click on f*inalize study* → Changing the data is not possible any more

In addition, it has been ensured that the assessment is saved automatically while using the app. In case of crashes or problems, the assessment can be continued at a later point in time. This feature allows coaches, for example, to enter personal data and thus 'prepare' the survey and carry it out at a later point in time.

In terms of content, the following labels for the curves were selected based on the salutogenetic health model (see Chapter 3.3.1) and the feedback from the first workshop:

- Health indicators
    - General state of health
    - Psychological well-being
    - Physical functioning
    - Athletic performance capability
- Stressors
    - Sport load
    - School load
    - Private burden
- Resources
    - Implementation of recovery measures
    - Implementation of injury prevention measures
    - Implementation of a sport-specific diet

However, these labels appeared to be too abstract and not differentiated enough for sports practice. Thus, we also compiled a battery with possible curve labels in preparation of the second expert workshop. During this workshop, we aimed to evaluate these labels through representatives from sports practice with regard to their relevance and usefulness (cf. Chapter 2.3.3, Table 5).

2.3.2 Preparation and Organization of Expert Workshop II

Based on the feedback from the first meeting, we decided to discuss the underlying theoretical assumptions of the biographical mapping approach and the possible application scenarios with representatives from sports practice in the second workshop. In this regard, we wanted to demonstrate the added value of a retrospective assessment – based on the assumption that thinking about the past has a decisive influence on future actions and emotions. Studies on coach behavior (Schubring, Bub & Thiel, 2014) show that past experiences can influence present behavior. A further advantage that we wanted to demonstrate lies in the conversation-supporting function of the approach, which enables athletes to visualize sensitive topics and gives coaches the opportunity to detect hidden events, patterns, and connections in an explorative manner.

Based on the results of the first workshop, we also wanted to discuss the question of when the biographical assessment should be carried out. Here, we wanted to propose the following three application scenarios for elite sports:

1. Initial assessment of new athletes
2. Assessment at the end of the season for evaluation purposes
3. Analysis of acute problems (depending on need and situation)

In addition, we aimed to present the correct usage of the software to coaches, athletes, and branch managers in one-on-one meetings. For this purpose, the assessment process (creating/deleting persons, entering biographical events, and selecting/drawing curves) and the analysis (selecting and comparing curves) was demonstrated exemplarily. In addition, we conducted an exemplary assessment with a volleyball player from our university in order to illustrate the different functions.

Finally, as described in the previous subchapter, we also wanted to evaluate the practical relevance of different developmental curves. For this purpose, we prepared a questionnaire in which we asked coaches, athletes, and representatives of the branch management to rate the different developmental curves on a 5-point Likert scale with regard to the perceived relevance (cf. following chapter, Table 5).

2.3.3 Implementation and Evaluation Expert Workshop II

The goal of this second, two-day expert workshop taking place from February the 14th to February the 15th, 2017 was the further optimization of the alpha version beside the points already mentioned. In this context, we sought feedback on the following points:

- Practicability and implementation requirements for the assessment
- Comprehensibility and visual design of the software
- Evaluation of the practical relevance of selected developmental curves

The basic software functions were explained to athletes and coaches as well as to the management of the branch office in one-on-one discussions. This included information on how to create a new person, enter biographically relevant events, and reconstruct the pre-selected curve courses (general subjective state of health, sport load, school load, athletic performance capability, quality of sport specific diet, difficulty of organizing daily life). In addition, the three identified application scenarios of the assessment tool (assessment of new athletes, evaluation at the end of the season, acute problems) and the initial idea that the reflection on past events has a decisive influence on the present experience and future action were explained once again. To illustrate this, an exemplary dataset was shown, which was also used to illustrate the analysis of the curves while taking into account the biographically relevant events. Feedback was obtained from each participant. Finally, all workshop participants completed a questionnaire designed to assess the practical relevance of selected curves.

In general, the software and the proposed application scenarios were received very positively. The underlying potential was recognized by both coaches and athletes. Especially the athletes showed great interest in the assessment tool. Table 4 shows a summary of the feedback of the workshop participants.

Table 4: Results workshop II

Results from the coaches' perspective	Results from the athletes' perspective	Results from the management's perspective
- Athletes have to enjoy the assessment and the added value has to be communicated clearly. - Athletes have to take the assessment seriously. → Coaches design their training in response to the results of the assessment. Hence, athletes can actively influence the training management. Dishonest answers affect the athletes negatively. → Thus, athletes have to be aware of the added value that has to be in the right relation to the required effort. - Mappings represent a good guide for the "end-of-the-season" talk because the athletes have the opportunity to reflect on their season in advance. This is good because usually there is not enough time for reflection during an athletic season. - Inter-individual comparison is important - For the future: Software could recognize critical life events and certain patterns so that the coach does not have to search for those. - Assessment should work independently of the coach.	- Mappings are a good tool for coaches who are new or not that experienced and who do not know the team yet. - Independent assessment after an introduction session is easily possible, but they need time for it. - Would prefer regularly scheduled assessments over shorter periods of time (after half a year or after the major sport competition) and a one-time assessment for longer time frames (to observe the development of their own biography and career). - Shorter time frames and more data collection points are perceived as important with regard to early intervention efforts. - Reflection on critical life events is perceived as added value. → Could also be used for oneself without the coach looking at it; tool for self-reflection on personal life and career development	- Athletes should be given enough time for completing the bioMap (could be done at home). → But should not take longer than 1 hour (limited time frame could be assessed and only a limited number of curves) - Shorter assessment frames are preferred. → Would be good if those could be combined into one biographical mapping at the end - Possibility to enter pre-determined events in advance that every athlete experienced and that were selected by the coach → Facilitates inter-individual comparison and could support memory and serve as an orientation point (e.g. training camps, important tournaments) - Results are also relevant for administration particularly when planning the competition and travel schedule (would enable them to take school load into account). - Several assessments allow to observe career development (regional league → 3rd league → 2nd league → 1st league). - Inter-individual comparison particularly important (compare the perception of the athlete with the one of the coach)

After the one-to-one discussions, we distributed the prepared questionnaires in order to assess the practical relevance of the proposed curves. The selection of the curve labels was guided by the information collected at the first meeting and the variables used in previous studies. The experts were asked to rate the practical relevance of each curve on a 5-point Likert scale, with values ranging from 1 = not important at all to 5 = very important.

The results (see Table 5) show both mean values and standard deviations. Since this is not an existing and validated questionnaire, a cut-off value of ≥ 4 was defined for curves that appear to be of particular importance. These are highlighted in bold in the table.

Also worth considering are the variables that were classified as quite important and had a value of ≥ 3 and < 4 (depicted in italic in the table).

Table 5: Descriptive statistics - expert ratings (n = 6)

	Min.	Max.	M	SD	Relevance
General health status	**4**	**5**	**4,67**	**,516**	**+**
Psychological well-being	**2**	**5**	**4,00**	**1,265**	**+**
Physical well-being	*2*	*5*	*3,83*	*1,329*	±
General well-being	*2*	*5*	*3,67*	*1,033*	±
Physical complaints	**4**	**5**	**4,83**	**,408**	**+**
Athletic performance capability	**4**	**5**	**4,83**	**,408**	**+**
Performance capability in school	**3**	**5**	**4,00**	**,894**	**+**
Sport load	**4**	**5**	**4,83**	**,408**	**+**
School load	**4**	**5**	**4,67**	**,516**	**+**
Burden from private life	*3*	*5*	*3,67*	*,816*	±
Perceived training load	*1*	*5*	*3,50*	*1,643*	±
Perceived competition load	*1*	*5*	*3,67*	*1,751*	±
Quality of injury prevention efforts	1	5	3,00	1,414	−
Quality of sport-specific diet	*2*	*5*	*3,67*	*1,033*	±
Quality of recovery measures	*2*	*5*	*3,50*	*1,378*	±
Pressure in sport	**2**	**5**	**4,00**	**1,095**	**+**
Pressure in school	*2*	*5*	*3,83*	*1,169*	±
Pressure through family	2	4	2,67	,816	−
Subjective relevance of sport	2	5	3,00	1,265	−
Subjective relevance of school	2	4	2,83	,983	−
Subjective relevance of digital networks	1	4	2,50	1,225	−
Relevance of athletic success	2	5	3,17	1,169	−
Relevance of success in school	2	5	3,17	1,169	−
Relevance of peer group outside of sport	1	4	2,50	1,049	−
Relevance of peer group within sport	2	4	2,67	,816	−
Relevance family	2	4	2,67	,816	−
Expenditure of time for sport	*1*	*5*	*3,50*	*1,761*	±
Expenditure of time for school	*1*	*5*	*3,67*	*1,751*	±
Expenditure of time for family and friends (face-to-face)	*1*	*5*	*3,50*	*1,643*	±
Expenditure of time for family, friends, follower (digital)	*1*	*5*	*2,83*	*1,722*	-
Support from family	*1*	*5*	*2,67*	*1,366*	-
Support from friends	*1*	*4*	*2,50*	*1,049*	-
Support from coach	*1*	*5*	*2,83*	*1,329*	-
Support from team	*1*	*5*	*3,00*	*1,414*	-
Well-being in the team	***3***	***5***	***4,17***	***,983***	**+**
Difficulty of organizing daily life	***2***	***5***	***4,17***	***1,329***	**+**

In addition, athletes proposed to also include a motivation curve for sports and school.

Summary and conclusion

Compared to the first meeting in September 2016, the added value of the bioMAP software became more obvious. A clear delineation of the underlying assumptions of a retrospective approach was particularly useful when illustrating the difference to other assessment instruments that usually aim for real-time recording with a prospective focus. Particularly the athletes who expected a kind of diary app at the first meeting were "positively surprised".

The three described application scenarios were received very positively, but more frequent assessments over somewhat shorter time periods were suggested. These regularly-scheduled assessments over an athletic season could then be supplemented by a longer assessment spanning one to four years. This would allow to identify biographical disruptions and compare the results of the different assessments with each other.

It proved to be extremely important to clearly communicate the benefit of a retrospective approach to the athletes. It is important to emphasize that the subjective evaluation of 'objective' events might differ between athletes and coaches. Instead of viewing this discrepancy as a problem, the identification of these differences might be really helpful because it helps coaches and athletes to better understand the perspective of the respective other.

All participants regarded the inter-individual comparison, e.g. within a team or between players on the same position, as an essential analysis tool. In addition, the perceptions of the athletes could also be compared with the coaches' perceptions.

The reflection on biographical events and the provision of these data to the coach, who then analyzes those, could form an important basis for coach-athlete talks and could noticeably increase their quality. The potential depth of information obtained through the assessment was perceived as very positive and participants believed that the tool could make a lasting contribution to individualized training management.

2.3.4 Development and Programming of a Beta Version

Based on the feedback provided during the second workshop, we concluded that the software development was on the right track with regard to content and visual design as well as usability. The further development of the presented alpha version to a stable beta version, which allows a completely functioning assessment without any troubles, was the next goal.

In close contact with our programmer, the software was further optimized and the initial troubles were eliminated. The basic functions of the alpha version remained largely the same or were partly extended. Table 6 shows the data collection process with the beta version.

Table 6: Process of data collection with beta version

1. Start screen: Open study
Project → Select an already existing project from the folder Message on how many persons were already registered in the project pops up → *OK* Afterwards, further tabs are opened in the headline Under the tab *Study* relevant study information is displayed (e.g. date of creation, date of change; scale of the x-axis, selected developmental curves)
2. Tab: *Create/ edit person*
Select existing person Add a new person → *New* → Enter first name and surname or pseudonym Delete existing person → *Delete*
3. Tab: *GesMap*
Can only be selected, when a person was chosen Enter critical life events → *Enter events* or double-click on the time line → Date, type of event (e.g. athletic, school, private), enter description and label Collect developmental curves → *Select curves* → Select curves *Draw* → Drawing the curves is only possible when the tab *Draw* is red → Draw the curves by hand (tablet) or with mouse (laptop)
4. Tab: *Analysis*
Select the curves to be depicted Events are displayed in different colors on the time line (e.g. athletic event = red); description of event is displayed in a pop-up window or if labelled, the labelled event is directly depicted
5. Tab: *Options*
Selected curve courses can be *exported as an image* *Export data into excel* *Finalize study* → Changing the data is not possible anymore

Particularly the feature to export the data into Excel is helpful for the subsequent data analysis.

2.3.5 Process Evaluation Phase II

After several minor revisions, a fully functioning beta version for use by coaches and athletes was developed. The very positive feedback during the second expert workshop encouraged us to collect data from around 20 young elite athletes in a third meeting scheduled for April/May 2017. We aimed to use the resulting knowledge for the fine-tuning of the software. Additionally, we decided to use the collected data for a first analysis in order to assess the potential of the assessment tool with regard to the identification of typical curve courses and patterns.

2.4 Project phase 3 – Tests, Documentation, and Design of a Release Candidate

2.4.1 Preparation and Organization of the Beta Test

The final phase of the project was characterized by a focus on the scheduled test of the beta version. Here, we aimed to use the new software to collect data from at least 20 young elite volleyball players at the German federal youth training base in Berlin. We had two objectives in mind: First, we wanted to test the software in a practical context to identify possible bugs. Second, we aimed to collect data that could be used for identifying typical behavioral and developmental patterns. This could serve as an interpretation tool for coaches in the long term.

To conduct such an assessment, we had to decide on the developmental curves we wanted to assess, their definition and their operationalization for the interview guide. Based on the feedback during the second workshop, we agreed to assess the developmental curves depicted in Table 7.

Table 7: Developmental curves - label, definition, and operationalization

Health indicators		
Label	*Definition/description*	*Operationalization*
Subjective health	Self-report or the general health status (cf. RKI, 2014)	How would you rate your general health status?
Physical complaints	Self-report of physical complaints (e.g. pain etc.)	What is the degree of physical complaints such as pain?
Athletic performance capability	Self-report of physical and mental performance capability in sport or of all abilities and skills that are needed to perform a task successfully (see Sargirli & Kausch, 2007)	How good is your athletic performance capability in general?
Well-being in the team	Own well-being within the sport team (cf. Lucas & Diener, 2008)	How satisfied are you within your team?
Motivation for training	Active and goal-oriented intention or willingness to start, maintain, and practice sport-related activities (cf. Becker-Carus & Wendt, 2017, p.486)	How motivated are you for training?
Motivation for school	Active and goal-oriented intention or willingness to start, maintain, and practice education-related activities (cf. Becker-Carus & Wendt, 2017, p.486)	How motivated are you for school?
Stressors		
Label	*Definition/description*	*Operationalization*
Sport load	All athletic influences and demands that affect the individual (on a physical, psychological, social level) → individual response = stress (see Krause, 2003, p.256; Van Dick & Stegmann, 2007, p.35)	How high is the burden you experience from sport?
School load	All education-related influences and demands that affect the individual (on a physical, psychological, social level) → individual response = stress (see Krause, 2003, p.256; Van Dick & Stegmann, 2007, p.35)	How high is the burden you experience from school?
Difficulty of organizing daily life	Subjectively perceived degree of coping with the demands of daily life	How difficult is it to organize and cope with daily life?
Quality of sport specific diet	Self-report of own diet (balanced diet, etc.)	How good is the quality of your diet?
Resources		
Label	*Definition/description*	*Operationalization*
Perceived support from family	Subjectively perceived social support from the family → help from others to stay healthy and feel well (see Gasser-Steiner & Freidl, 1995, p.69-71)	How high is the perceived support from your family?
Perceived support from coach	Subjectively perceived social support from the coach → help from others to stay healthy and feel well (see Gasser-Steiner & Freidl, 1995, p.69-71)	How high is the perceived support from your coach?

Based on these reflections, we developed an interview guide for the assessment, which also included questions on the perception of the assessment tool and the interview itself. The feedback provided in response to the latter questions could then be used for finalizing the software. In addition to the biographical mapping, two health-related questionnaires, namely the Salutogenetic Health Indicator Scale (SHIS) and the EQ-5D-3L, were included. In addition, sociodemographic and sports context-related information was collected using a part of the GOAL questionnaire (cf. Thiel et al., 2011).

We pretested the software and the interview guide for practicability and comprehensibility with a semi-professional cyclist. This only resulted in minor changes to the procedure. Overall, this test demonstrated that the biographical mapping method stimulates detailed self-reflection and that after a brief adjustment period, the participant quickly got used to the software.

2.4.2 Performing the Beta Test in the Field

The beta test took place from April 25th to April 27th, 2017 at the German federal youth training base for Volleyball in Berlin. The software was tested with 24 athletes (12 females, 12 males). The interviews were conducted by three trained scientific project staff members. The athletes were informed about the goal of the study before the interview and anonymity was assured. All conversations were recorded with a digital recording device. The duration of the interviews ranged from 45 to 90 minutes.

2.4.3 Results and Evaluation of the Beta Test

The scientific team had the following impressions with regard to the methodological procedure: A differentiated approach makes sense for the recording of biographically relevant events. On the one hand, open questions should be asked ("What do you remember from last year?"), but on the other hand, it is also of help to collect standard events that do not have to be of personal relevance (such as the beginning of the season, end of the season, beginning and end of the school year, holidays, major sporting events). In addition, it is often necessary to enter individually significant events over the course of the assessment (e.g. relevant events mentioned with reference to a certain curve), and not only at the beginning of the interview. With regard to the curve labels, a clear and unambiguous description or definition is necessary.

One limitation is the fear of the athletes to say or enter anything 'wrong'. This often resulted in memory gaps. In addition, we observed that athletes rarely talked about private events. Accordingly, this area of the biography remains hidden. In this respect, further investigations with an explicit focus on private events would be useful. Finally, it should be discussed what the interviewer is allowed to do with the data after data collection. For example, it remains to be discussed whether the interviewer is allowed to enter additional information from the interview material (that was not entered during the interview because of a lack of time and the fast progression of the interview) or whether the interviewer is allowed to smooth curves (when the drawing did not work well and unwanted peaks occurred). These points are particularly important when the software is used as a scientific assessment tool; they might not be as relevant for a practical application scenario.

The athletes' feedback with regard to the software and the interview was consistently positive. For example, the handling of the software was perceived as very intuitive and the athletes really enjoyed drawing the curves and completely forgot the time when doing so. In many cases, we noticed that drawing the curves was easier than talking about the topics. The drawn curves in turn encourage self-reflection, which can often be used by the interviewer for further conversation, particularly about sensitive topics.

The pre-defined curve dimensions were perceived as very good. There were hardly any suggestions for improvement in this respect. With regard to the 'subjective health' curve, however, it was suggested to make a distinction between physical and psychological well-being. In addition, athletes proposed to conduct the assessment at shorter intervals (e.g. every three months or every few weeks) in order to gain more precise assessments of health-related developments. Furthermore, athletes seemed to be highly willing to use the software independently of their coaches. Some athletes asked whether the instrument would be made available to them personally.

2.4.4 Further Development of the Beta Version to the Release Candidate

The field test of the beta version confirmed that a functional and easy to understand version of the bioMAP software was developed. Only during the initial analysis, the scientific team recognized a need for optimization in a few areas. In consultation with our programmer, software changes had to be made with regard to the Excel export feature and the depiction of biographical events on the x-axis. In addition, a solution was to be found for merging several data sets collected on different devices.

After solving these problems, the beta version was further developed into the final release candidate. This software version is now ready for use both for scientific research as well as elite sports practice.

2.4.5 Process Evaluation Phase III

At the end of the third project phase, the central objective of the service project, namely the development of an analytical tool that enables intra- and inter-individual comparisons of complex, biopsychosocial health trajectories of young athletes was achieved. With the development of the bioMAP software, coaches and scientists now have a tool at their disposal, which enables a simple recording, immediate analysis, and interpretation of health-related developments.

Based on the results of the field test, a user-friendly and easy-to-use software was developed that is very popular with the athletes. The intuitive handling when drawing the curves stimulates reflection and supports athletes in the critical examination of their own biographies. In this sense, the bioMAP method provides a benefit for coaches and scientists (knowledge gain) as well as for athletes (self-critical reflection).

3 Description of the Developed Software

3.1 Functions

The bioMAP software is an instrument for the retrospective analysis of complex, biopsychosocial health trajectories in (young) competitive athletes. Based on the biographical mapping method, subjectively significant life events are recorded and entered in a two-dimensional coordinate system on the x-axis, which is scaled to a fixed time span. The y-axis represents an intensity scale ranging from 0 to 10. The entered life events and phases serve as orientation points for the athletes when they are asked to assess different health dimensions with regard to their subjectively perceived intensity over the time span depicted in the biographical mapping. The drawn curves visually represent the development of the respective health-related dimensions (see Fig. 2).

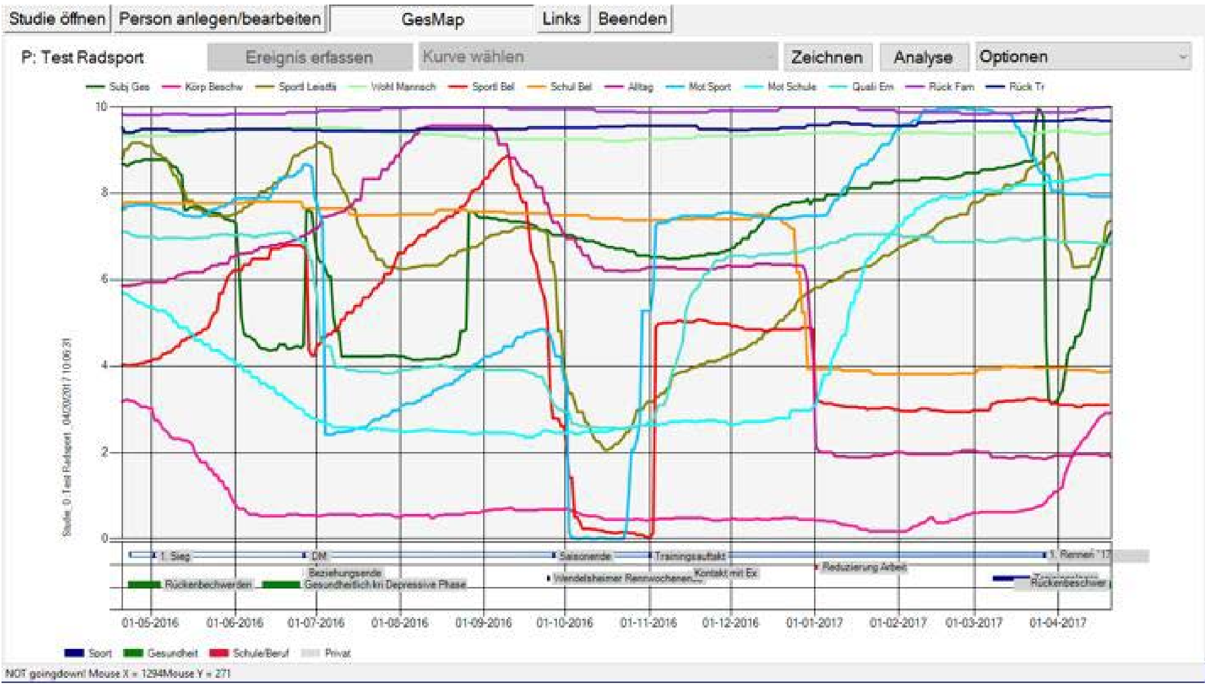

Figure 2: Exemplary result of a bioMAP assessment

3.2 Manual

The software can be installed on a Windows-based tablet. Via the touch screen, it can be operated with simple finger movements or the stylus. In addition, the software can be used on any Windows laptop or PC. Here, it can be operated using the keyboard and the mouse or trackpad. The following chapter describes the use of the bioMAP software.

Technical Background

Basically, the bioMAP software consists of two elements. One is the software itself. Like any other software program, it can be opened via the bioMAP symbol after installation on the tablet, laptop, or PC. The second component consists of a file that determines the content of the software. It contains all relevant study information, such as the current study name, the time scaling of the x-axis, the curve labels and colors, as well as the event categories and colors. This file is in xml format and can be edited via the Windows editor (right click on the xml file and select Open with editor) and modified according to the study design. For example, the study name can be changed, the period to be investigated can be scaled to the desired length (week, month, year, several years, whole life span), and curves and event categories (depending on the research interest) can be added or deleted. Please make sure that the format in the xml file is retained (see Fig. 3).

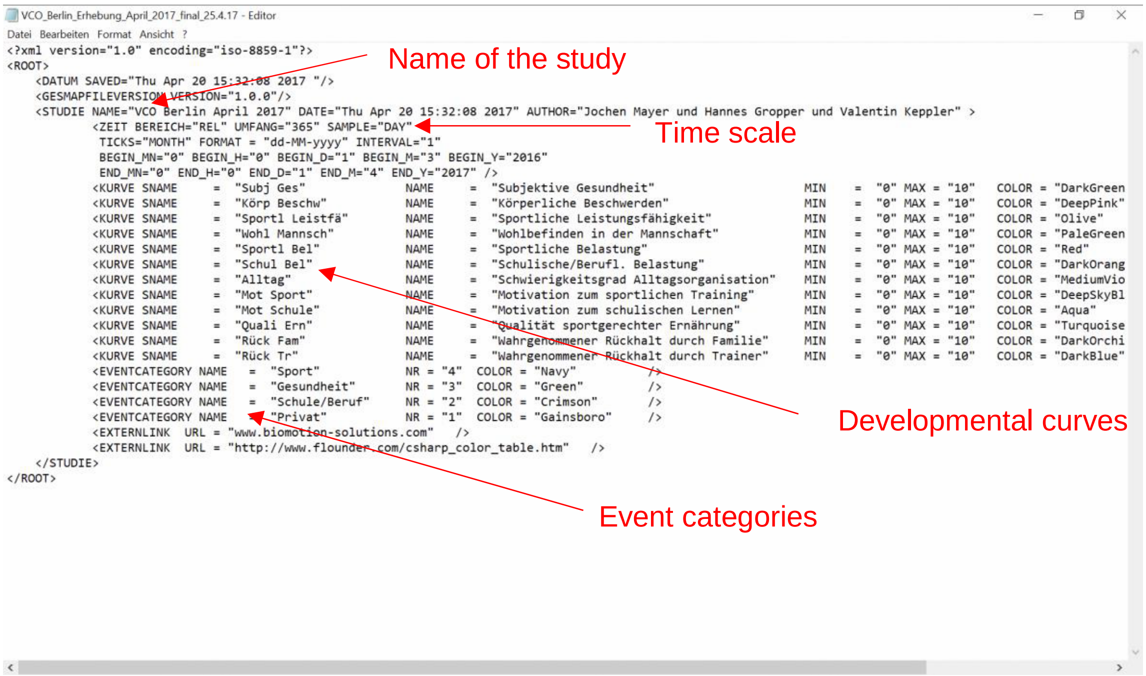

Figure 3: Editor view of an xml file with all study information

If data are entered in the 'actual' bioMAP program during the assessment (e.g. persons are created or curves are drawn), the program automatically generates an additional folder which is saved under the study name with the suffix .data. This folder updates itself, is stored in the same place as the xml file described above, and contains all study-specific data (e.g. information on persons created). In addition, screenshots and Excel exports are stored in this folder (see Fig. 4).

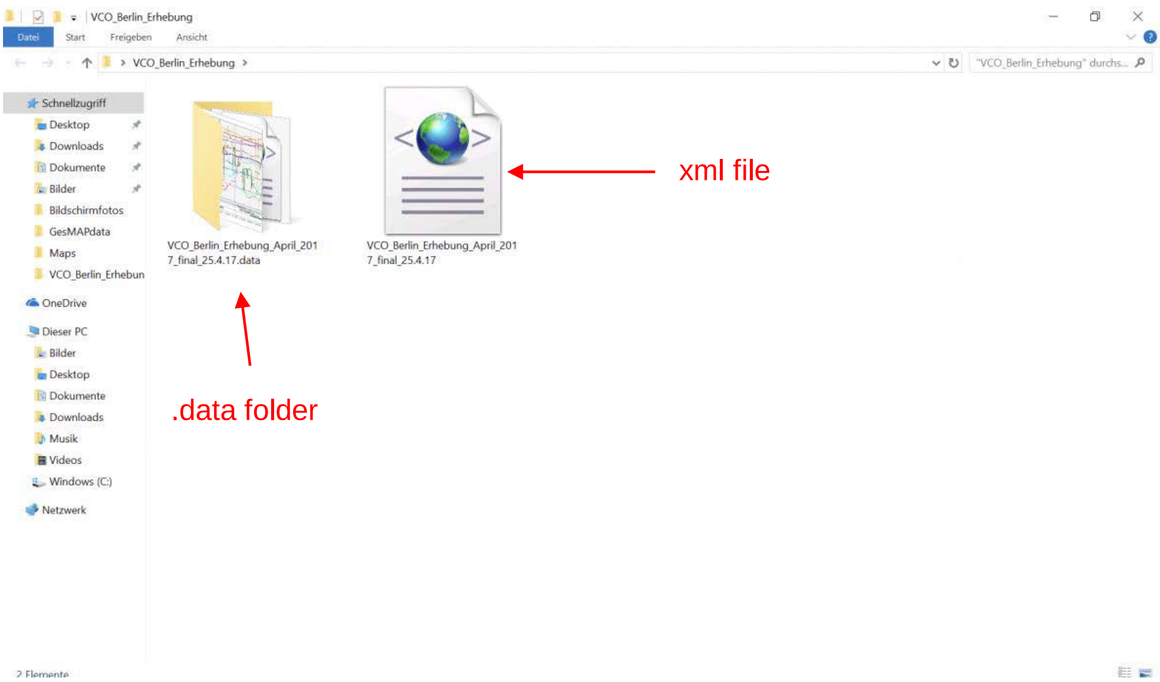

Figure 4: View xml file and the corresponding .data folder

For a new study or for a new participant, it is recommended to create a new xml file with a new study (or participant) name (see above). This will automatically save new assessment data in a new folder. In the following, we will describe the nine steps that are necessary when conducting an assessment with the bioMAP software.

Step 1: Create project and define study specifics

To create a new project, the xml file must first be adapted to the specifics of the study in the Windows editor as described above. At this stage, the study name, time scale, curve labels, and event categories must be defined. To avoid confusion with other projects, it is recommended to assign a unique file name to the xml file (right click on xml file, select Rename and enter new file name).

Step 2: Open the software and start screen

To open the software, first select the program bioMAP. The following start screen appears (see Fig. 5).

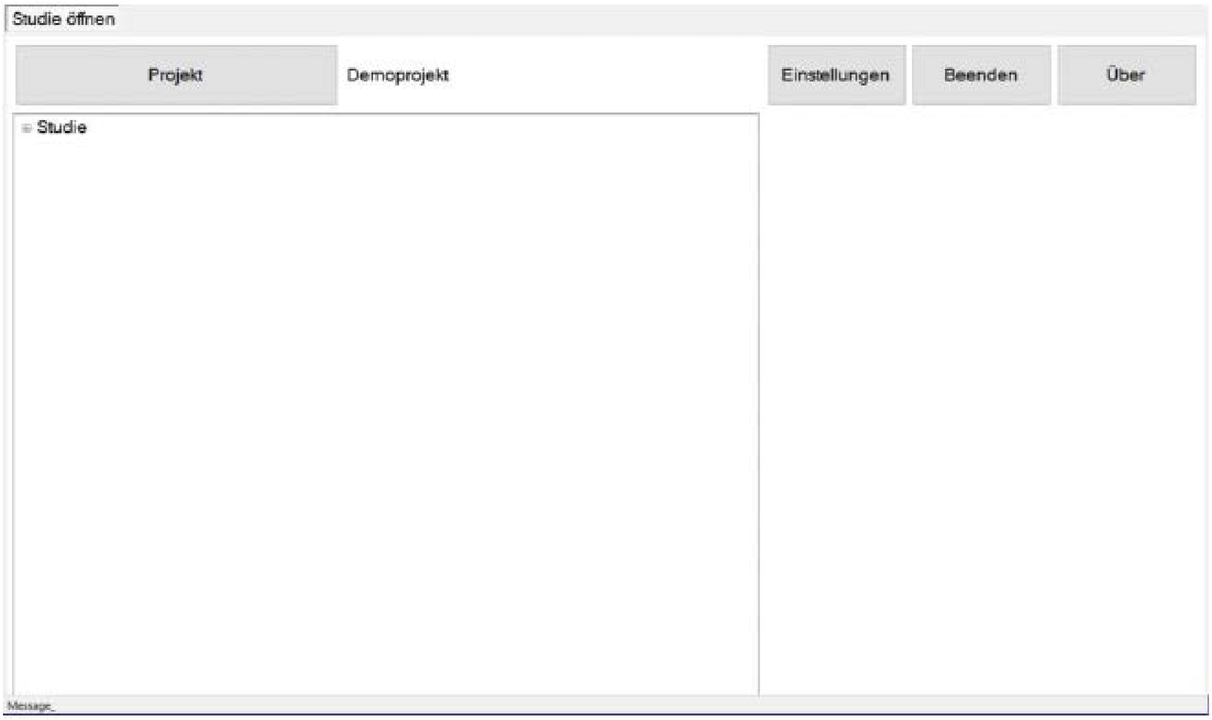

Figure 5: Start screen after opening the bioMAP program

Step 3: Opening a project

To open the already created project, select the Project [*Projekt* in German] button (see Fig. 6).

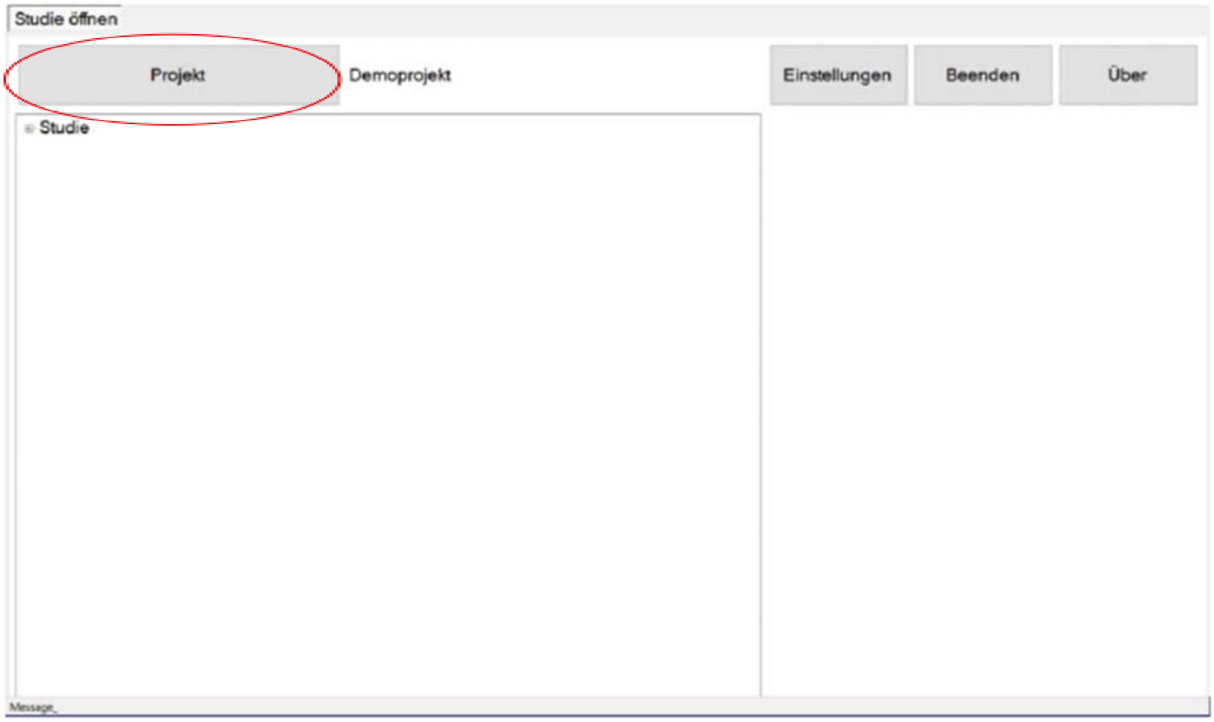

Figure 6: Start screen and open created project

A window opens in which the folder and program structure of the used device (laptop, tablet, or PC) can be viewed and from which the desired study file (in xml format) can be selected (see Fig. 7).

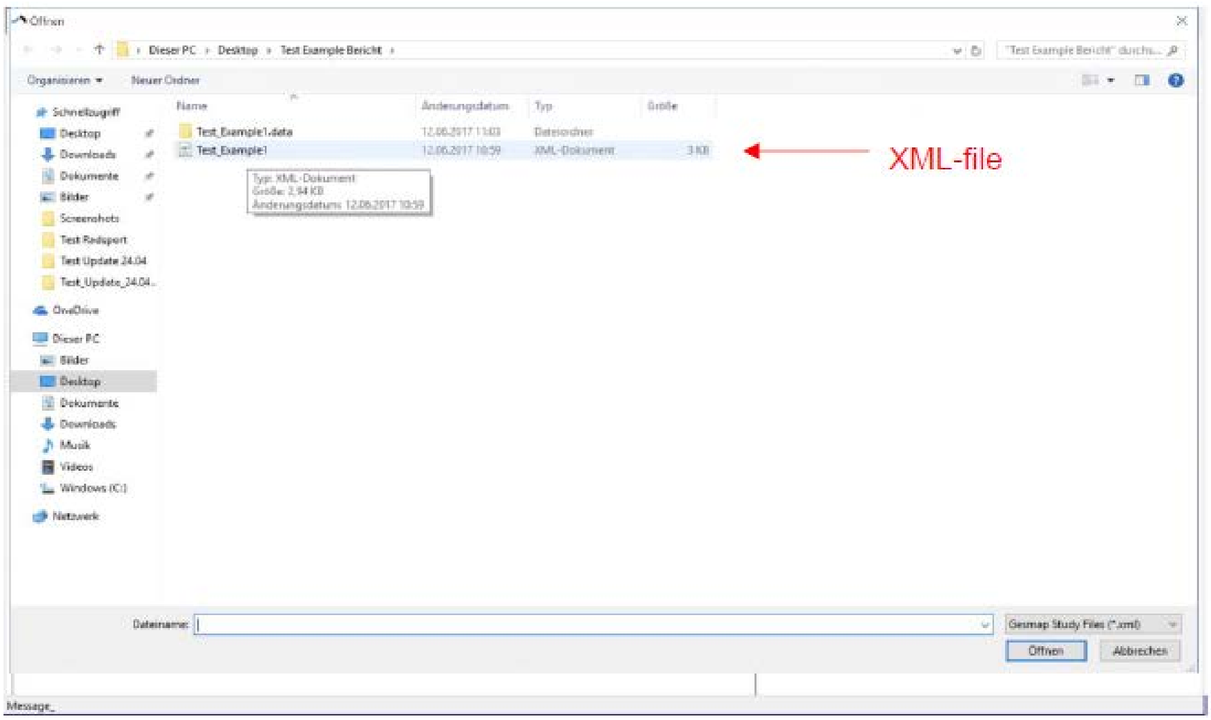

Figure 7: Folder view for opening the xml file

After selection, a message appears that indicates the number of persons that have already been created in the opened study. This message must be confirmed with *OK*.

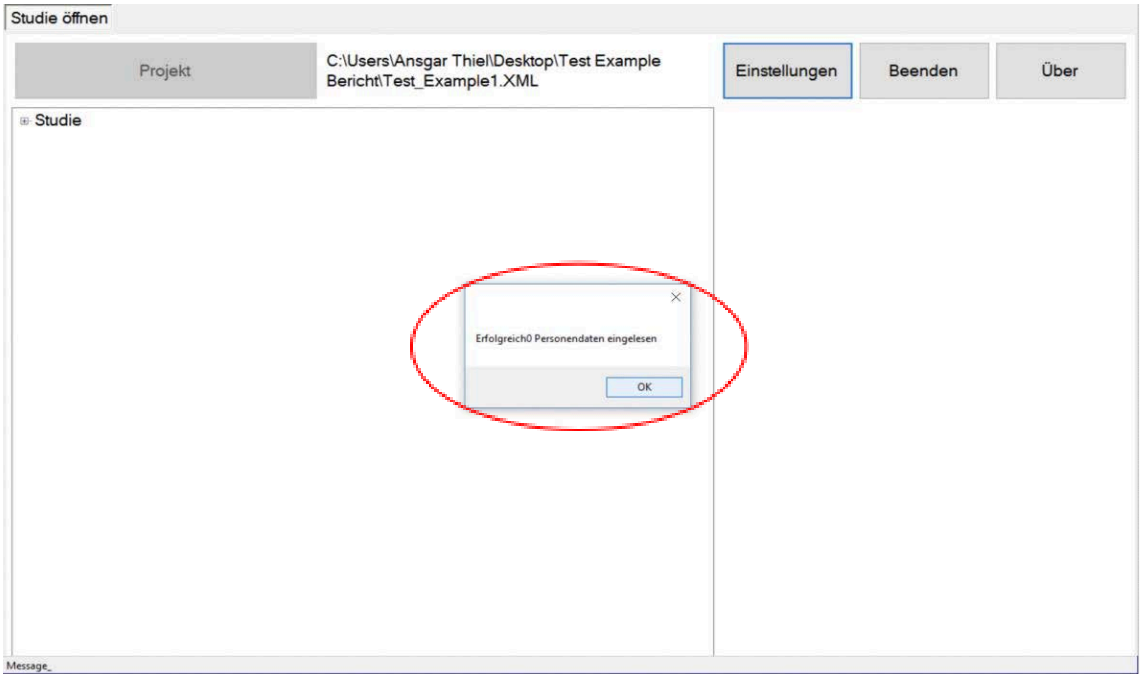

Figure 8: Report on the number of persons created in the study

With the tab *open study [Studie öffnen]*, a drop-down menu with all relevant study information as defined in the underlying xml file can be opened via the item *study [Studie]* (see Fig. 9).

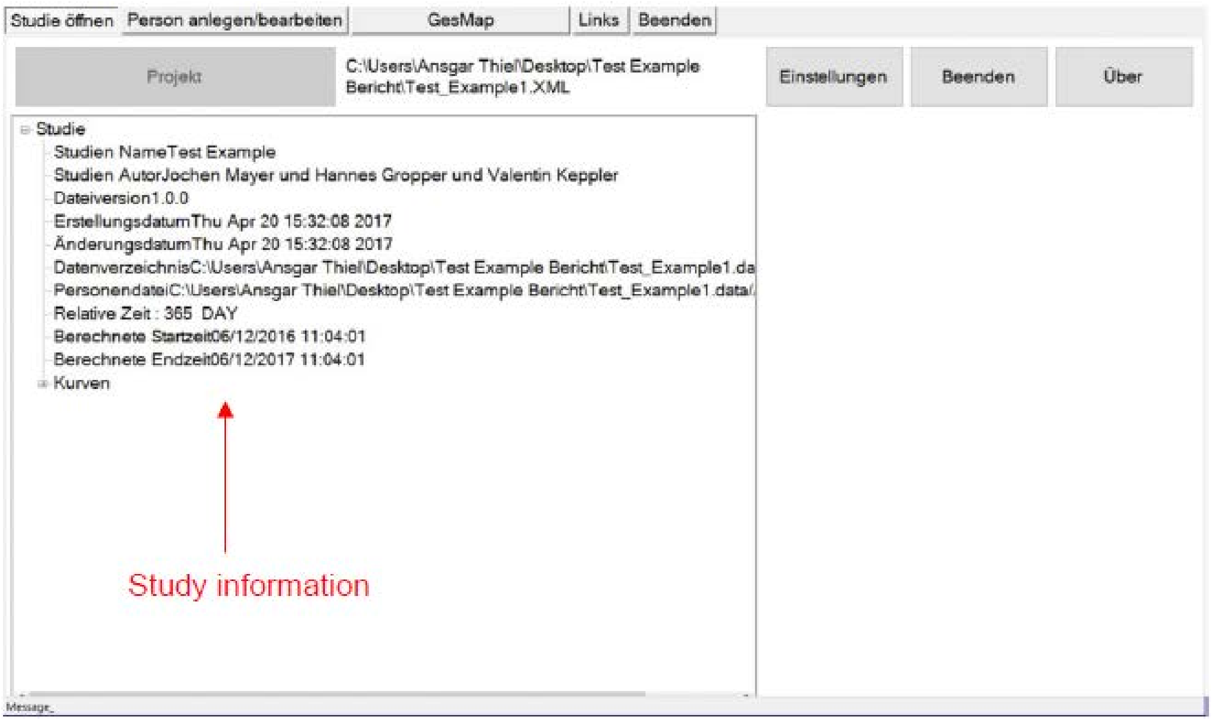

Figure 9: Drop-down menu with all relevant study information

Step 4: Create and edit persons

In the tab *Create/Edit Person [Person anlegen/bearbeiten],* all persons that have already been created are depicted on the left. Using the *New [Neu]* and *Delete [Löschen]* buttons, you can create new persons or delete existing persons. The *Rename [Umbenennen]* button can also be used to rename created persons (see Fig. 10). However, we would suggest to always create a new xml file for each study participant and not use the described feature (this is particularly relevant when assessing the whole life span and having participants of different age).

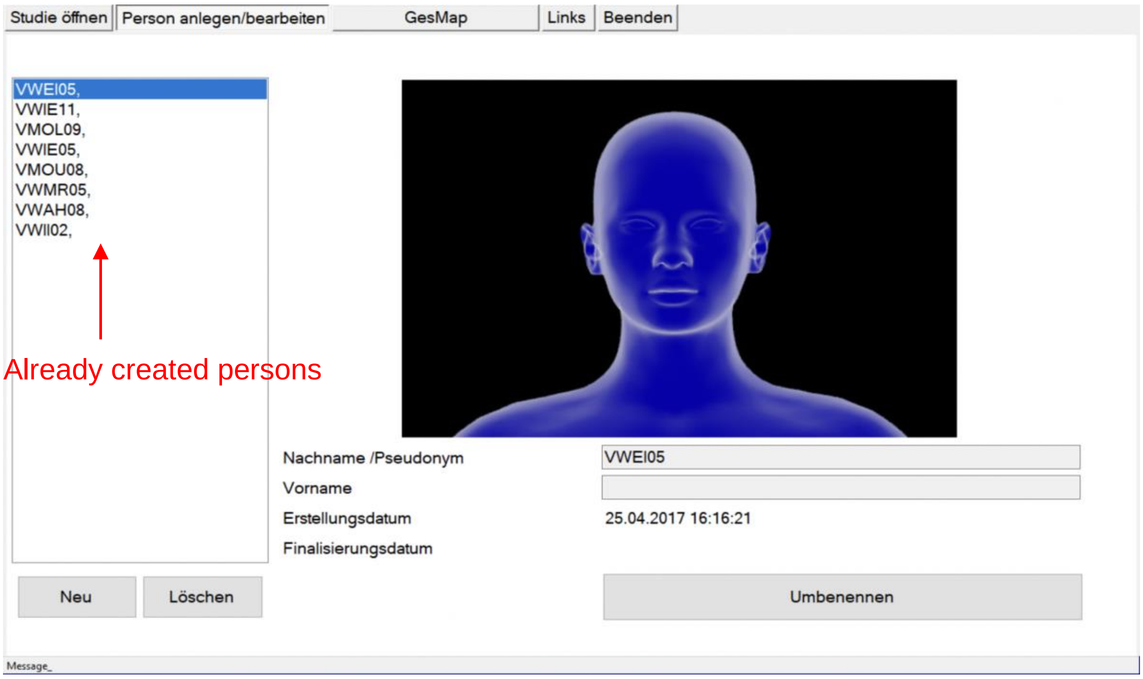

Figure 10: Create/Edit Person tab with already created persons (pseudonymized)

If a new person is to be created, a window opens in which the first name [*Vorname*] and surname [*Nachname*] or a pseudonym can be entered. Only the input of a surname or a pseudonym is obligatory, the input of a first name is optional. The creation of a pseudonym is not obligatory here, but for reasons of data security explicitly recommended. After entering the personal data, they must be confirmed by clicking the *Apply* [*Übernehmen]* button. By clicking on the 'dummy picture', a profile picture of the created person can be added (see Fig. 11).

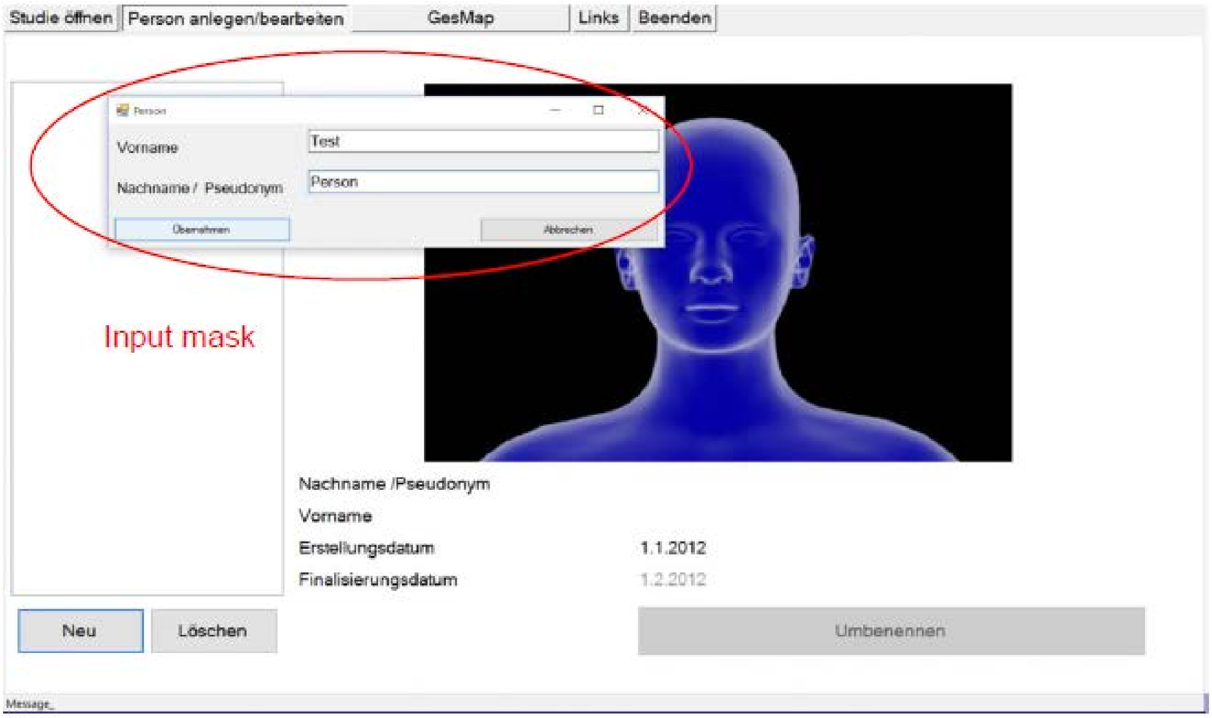

Figure 11: Input mask for creating new persons or renaming already created persons

As already described at the beginning, all changes made in the program are simultaneously saved in the study folder assigned to the respective project (e.g. list of persons and corresponding personal data).

In order to be able to continue working with a specific person in the bioMAP program, this person must be selected from the list of created persons (selected persons are highlighted in blue).

Step 5: Enter biographically relevant events

The main part of the software can be found under the ‘GesMap’ tab. Here, a work surface opens in which the central two-dimensional coordinate system is displayed. Above the coordinate system, one can find a menu, which shows the name of the opened person (or the pseudonym), as well as buttons for further actions (*record event [Ereignis erfassen], select a curve [Kurve wählen], drawing [Zeichnen], analysis [Analyse], and options [Optionen]*). Below the the x-axis, one can find the predefined event categories (in this example: sports, health, school/work, and private) (see Fig. 12).

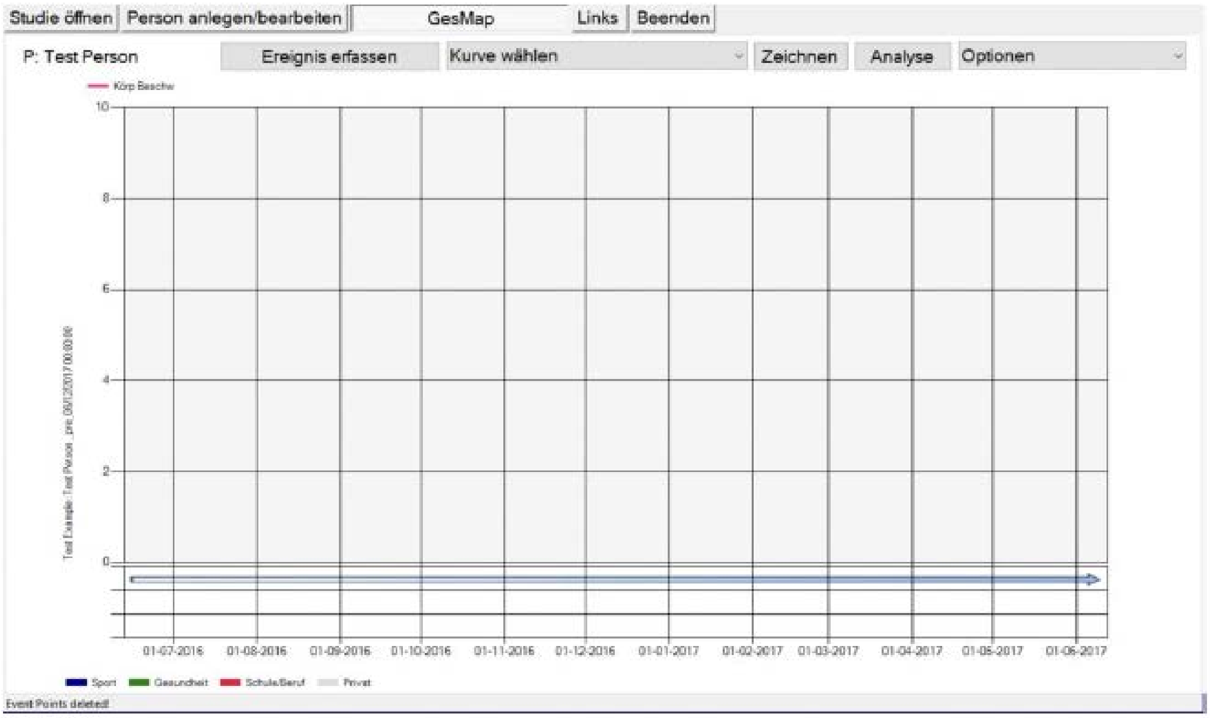

Figure 12: Coordinate system for the collection of the curve courses

The first step of a biographical mapping interview is to collect biographically relevant life events of the interviewees within the time span depicted on the x-axis. Events can be entered either by double-clicking on the field below the x-axis or by clicking on the *record event [Ereignis erfassen]* button. For this purpose, an input mask opens (see Fig. 13) in which the following information can be entered:

- Selection of the event category via drop-down menu (sport, health, school/job, private)
- Select the type of event by ticking the box (singular or phase)
- Determining the date of the event or time span (start and end) by means of a calendar
- Description of the event in the central text field
- Optional: Enter a label that will later be displayed on the x-axis
- At the end, confirm all changes *[Bestätigen]*

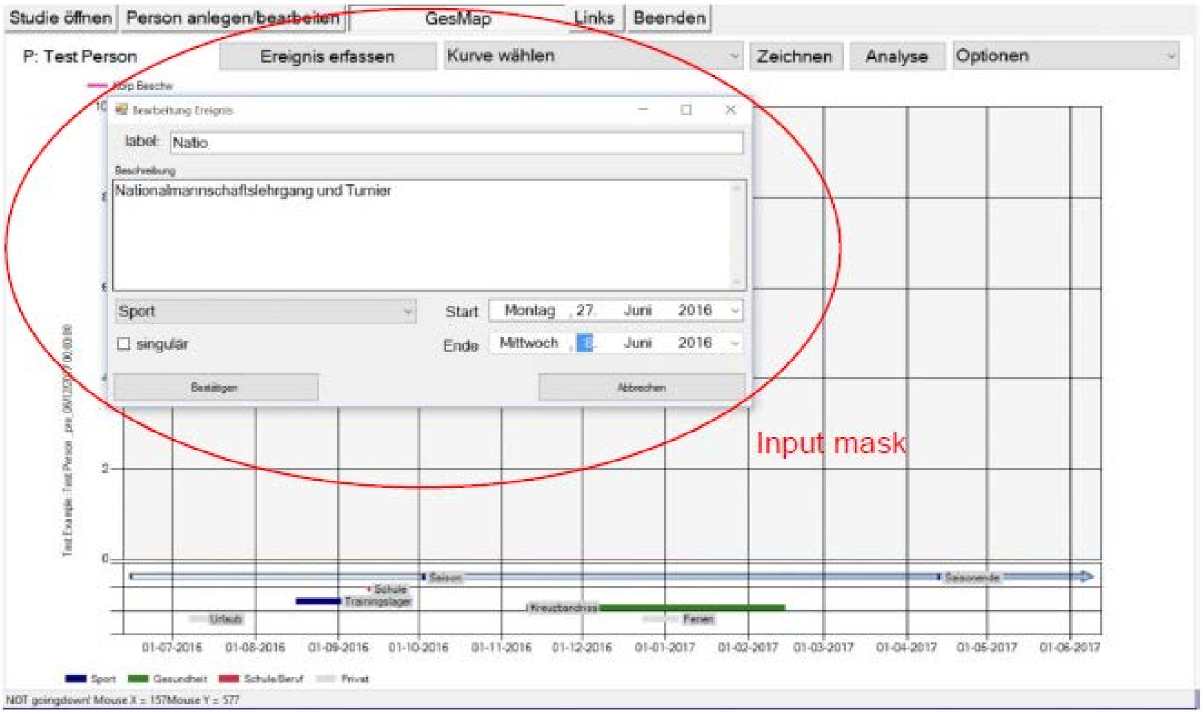

Figure 13: Input mask for recording and describing biographically relevant events

After input, the biographical events are displayed as bars below the x-axis in the color of the respective event category (see Fig. 14). If an event label has been entered, it is displayed at the height of the bar. By tapping or briefly pausing with the mouse on the corresponding bar, a small pop-up window opens, which shows the description of the respective event.

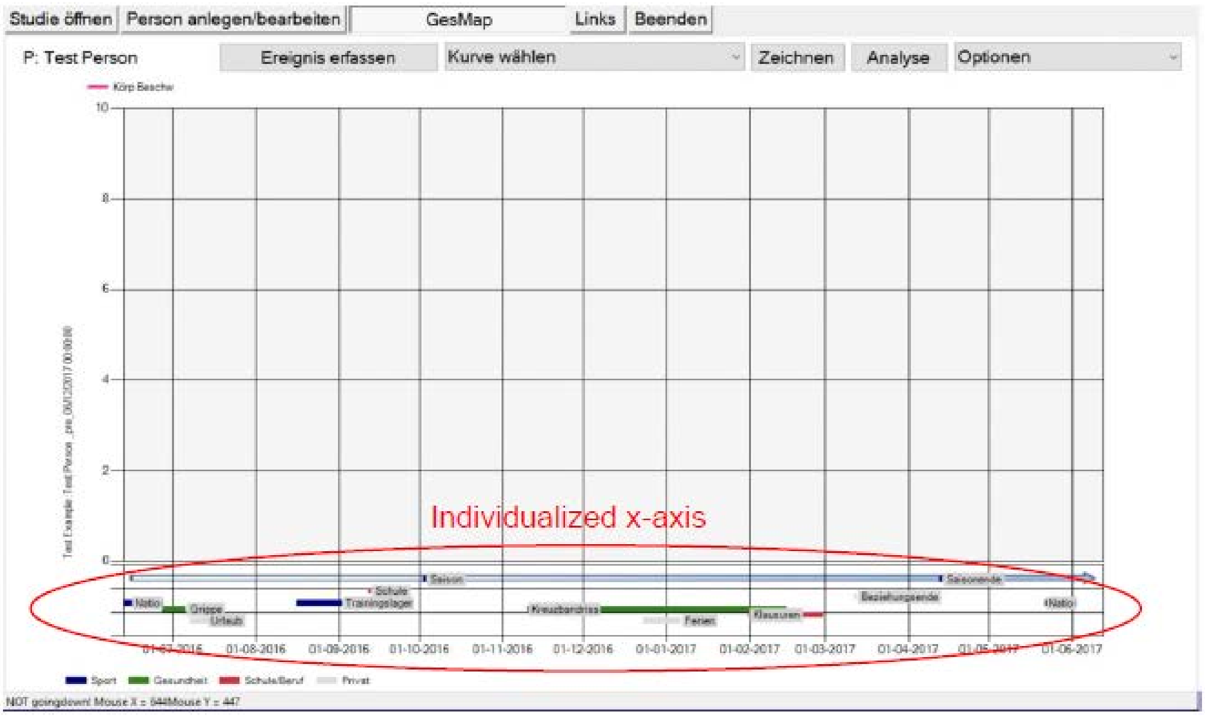

Figure 14: Coordinate system with individualized x-axis

Double-clicking on an event or phase opens a new window with the options *Edit event [Ereignis bearbeiten]* to make changes and *Add event [Ereignis hinzufügen]* to add new events that happened at a similar time (see Fig. 15).

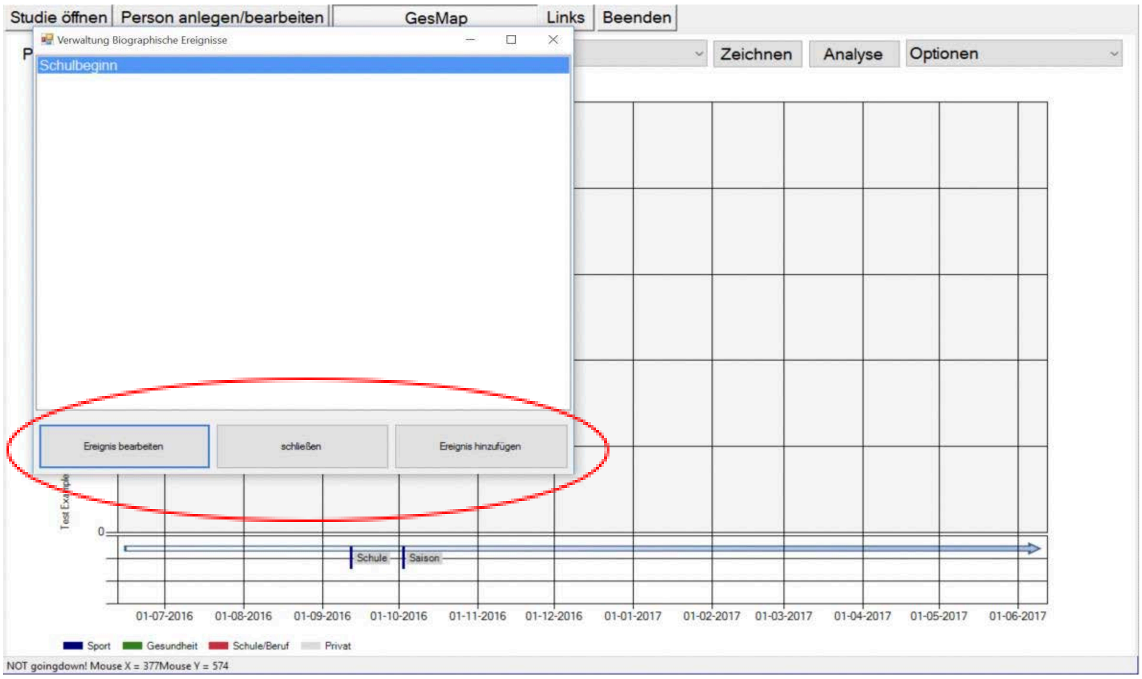

Figure 15: Menu window for editing or creating new events

Step 6: Draw curves

To be able to draw the curves, the respective curve must be selected via the menu item *Select curve [Kurve wählen]* (see Fig. 16).

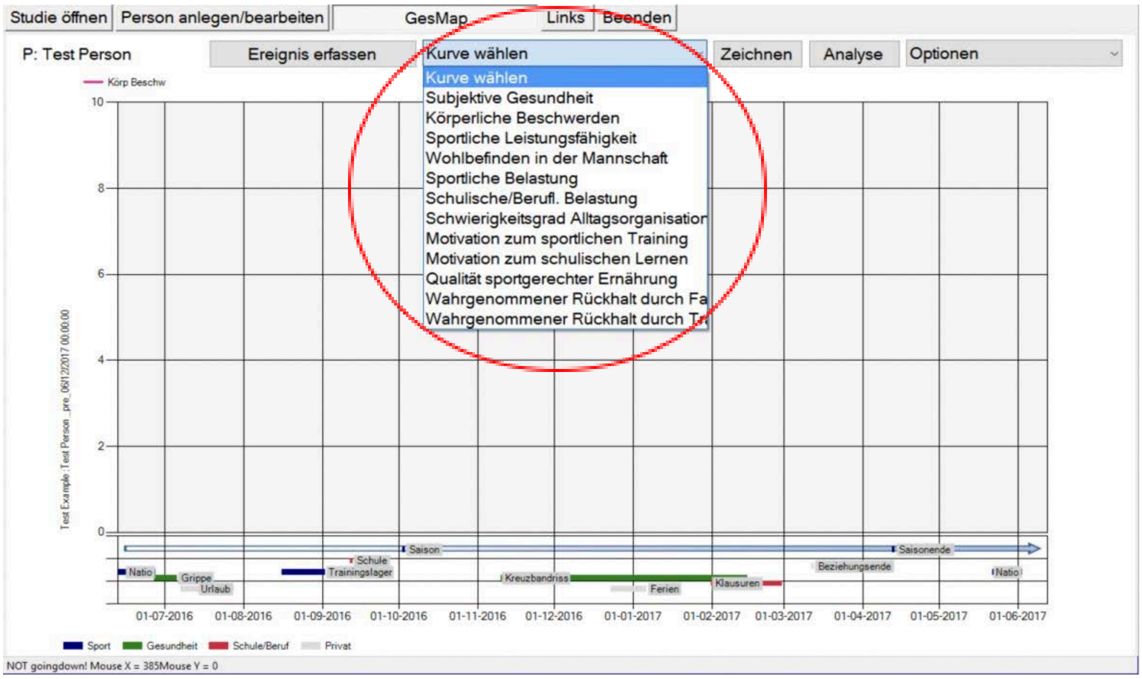

Figure 16: Selection of the curve to be drawn

To draw, the button *Draw [Zeichnen],* which is highlighted in green after curve selection, must be operated by clicking on the button. If the button is highlighted in red, you can draw. In addition, the interviewees are asked to reflect on the drawn curves. This reflection should be encouraged while drawing the curves in the form of “thinking-aloud”. However, if participants are overwhelmed and prefer to draw the curve first, it is the task of the interviewer to encourage reflection on the curve course afterwards by asking for explanations of highs and lows (see Fig. 17).

Figure 17: Exemplary curve course of the dimension “subjective health“

Repeating this step several times allows to collect all predefined curves in the given (or also another) order.

Step 7: Complete the assessment

Before finalizing the mapping, it should be verified that all relevant events and curves have been recorded. The *Options [Optionen]* button opens a drop-down menu, which contains the export functions and also the option *Finalize the mapping [Map finalisieren]* (see Fig. 18). If one aims to finalize the mapping of the respective person, this step must be approved in a confirmation field. Subsequent editing of the curves and events is then no longer possible.

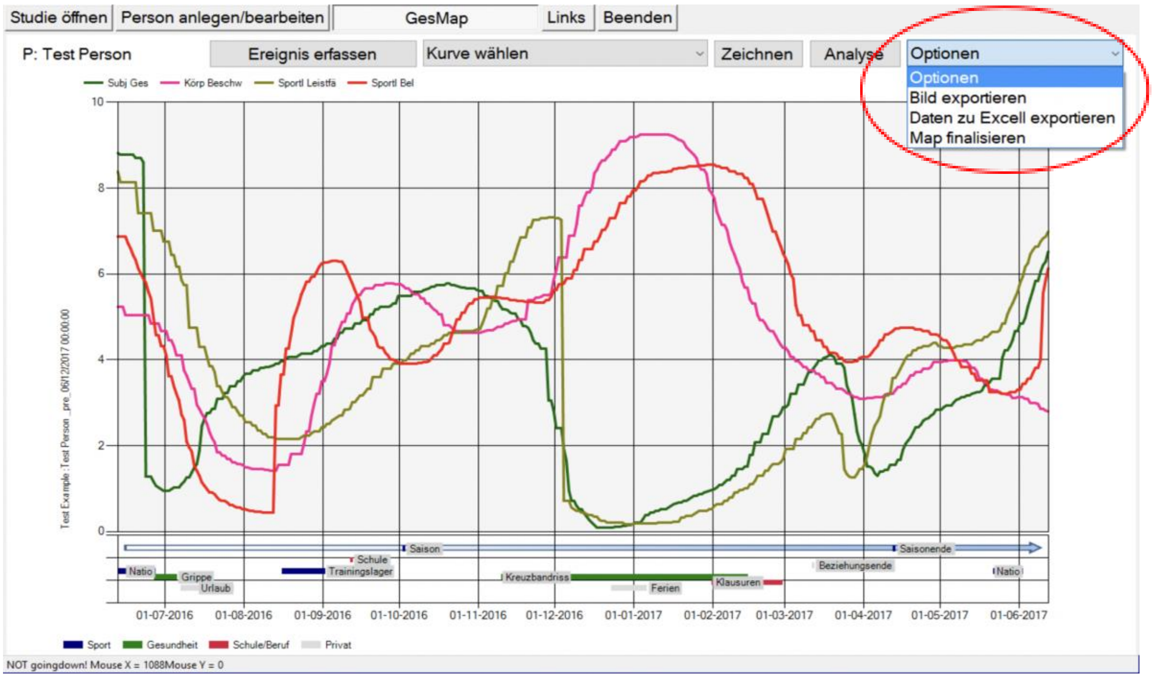

Figure 18: Options - Finalize map

Step 8: Analyze curves

The *Analysis [Analyse]* button allows to qualitatively analyze the collected data directly in the software. Curves can be selected and analyzed in relation to each other (e.g. parallel or opposite curves) and to biographical events (e.g. maxima and minima) (see Figs. 19 and 20).

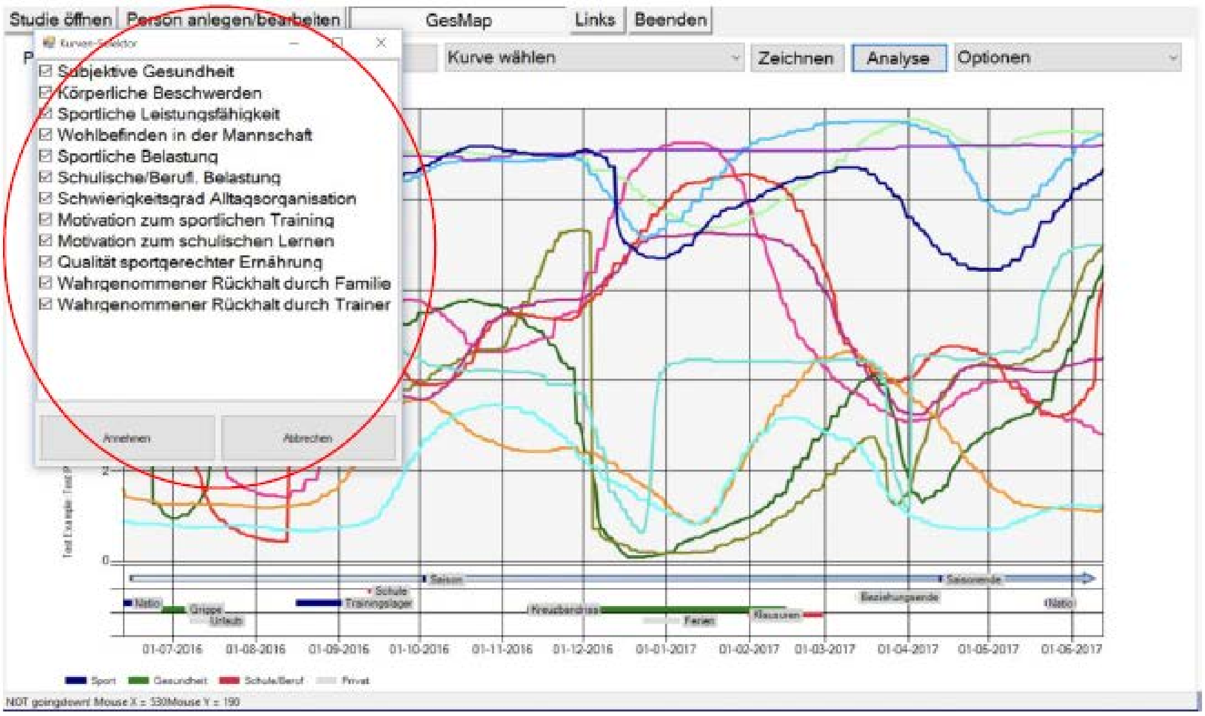

Figure 19: Analysis - Selection of curves

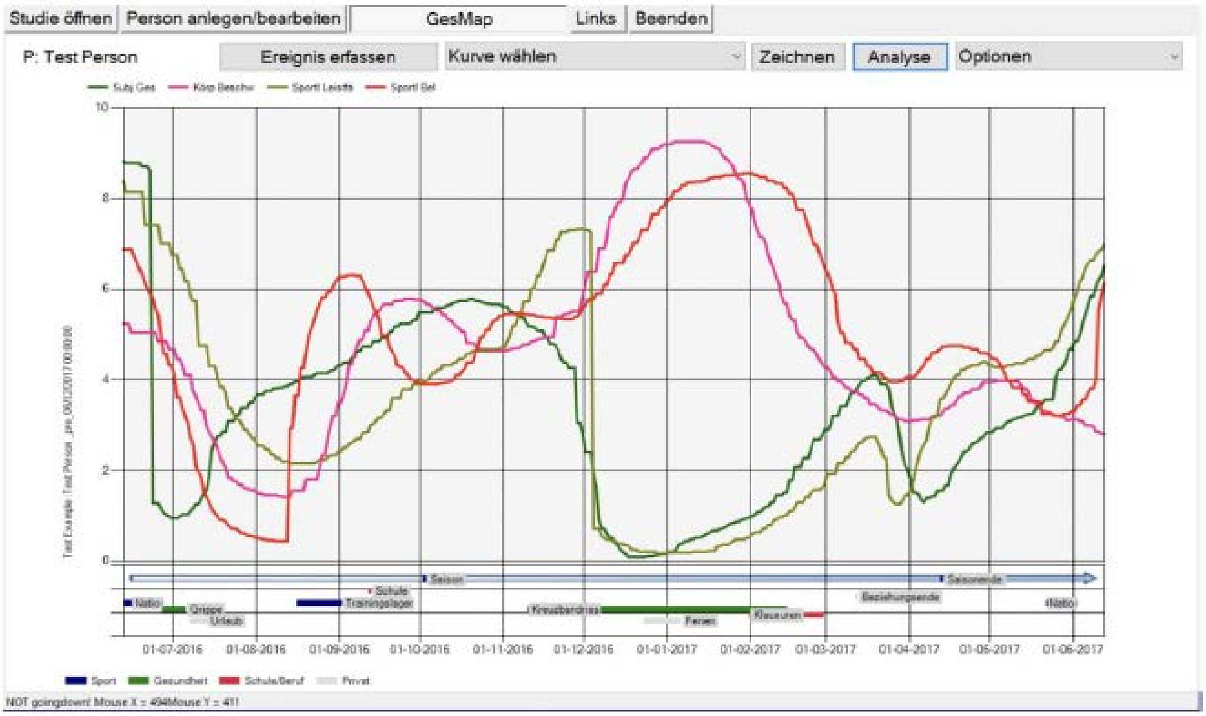

Figure 20: Analysis - Comparison of four curves and their relation to biographical events

Step 9: Export results

In addition, the results can be exported. Via the *Options [Optionen]* button, the mapping can be exported as a jpg image file (menu item *Export image [Bild exportieren])* and as an Excel file (menu item *Export data to Excel [Daten zu Excell exportieren]).* A new file is created in the study folder, which is based on the name of the person (depicted at the left of the coordinate system in the case of image export) and on the name of the study in the case of an Excel export (see Fig. 21).

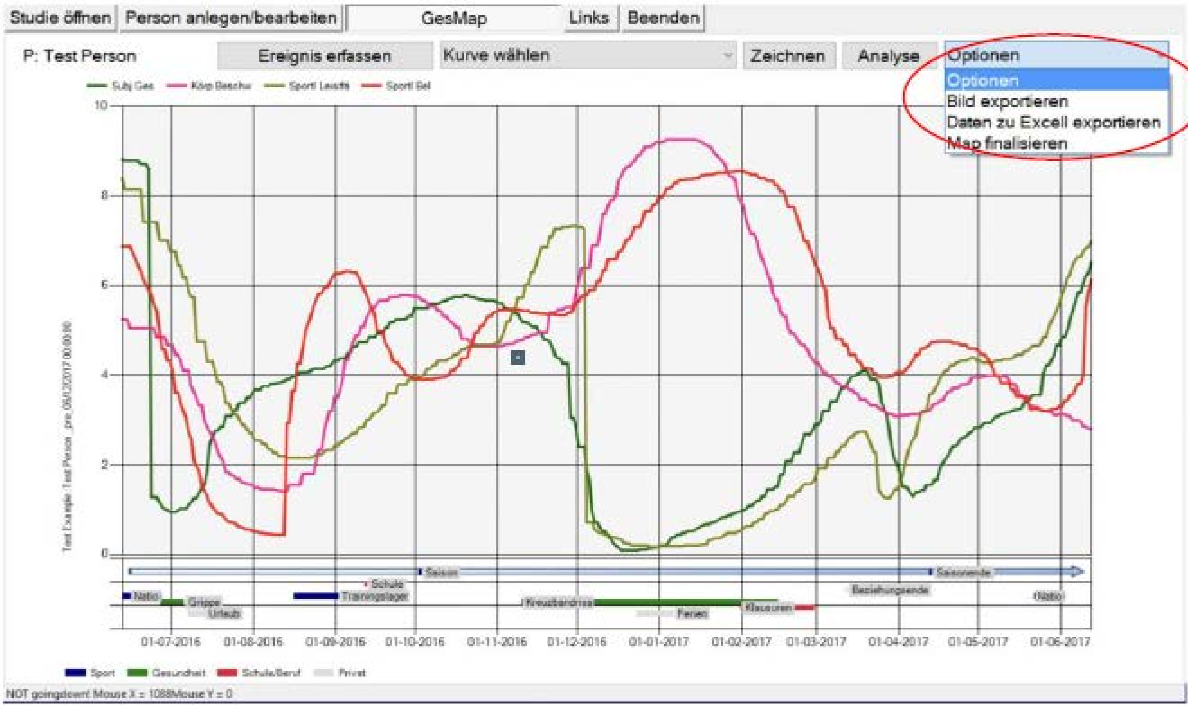

Figure 21: Export options as image or Excel file

3.3 Analysis Options

In addition to the software development, a theoretical framework for the interpretation of the biographical mapping data was developed during the project. This framework is based on the salutogenetic health model and can be used as an explanatory model for analysis in research as well as a model for data interpretation in the everyday practice of elite sports.

3.3.1 Adaptation of the Salutogenesis Model

The salutogenesis model by Aaron Antonovsky is a prospective approach to maintaining and promoting health. The salutogenetic model marks a paradigm shift in that it focuses on health rather than on disease. This is based on a new understanding of health. While pathogenetic models consider disease as an exception and health as the normal case, Antonovsky assumes "that the human system (as all living systems) is inherently flawed, subject to unavoidable entropic processes and unavoidable final death" (Antonovsky, 1996, p. 13).

The inherent tendency in human nature towards entropy and (biological) decay represents the axiom of salutogenesis. Thus, Antonovsky dissolves the dichotomy between healthy and sick and includes all humans irrespective of their health condition in his model. Based on the assumption that some people are healthier than others, people are located at different points on a 'multidimensional health continuum'

(Faltermaier, 2005). This continuum depicts the individual's state of health between the two poles *Ease* and *Dis-Ease* (Mittelmark & Bull, 2013). The continuum is believed to be multidimensional because health is a highly complex phenomenon influenced by various factors: "All human distress is always that of an integrated organism, always has a psychic (and a social (...)) and a somatic aspect" (Antonovsky, 1996, p. 11). Herewith, the model of salutogenesis follows Engel's biopsychosocial understanding of health (1979), which points out that illness is more than just a biochemical deviation and that, among other things, individual living conditions have a considerable influence on the state of health (cf. Faltermaier, 2005, pp. 48-49).

These assumptions are reflected in Antonovsky's salutogenetic model. The central building blocks of his conception are the socio-cultural and historical context in which an individual lives his or her life, the individual biography developed within this context, existing (psychosocial and genetic-constitutional) resistance resources, potential (psychosocial and physical and biochemical) stressors, as well as an individually distinctive sense of coherence (see Fig. 22).

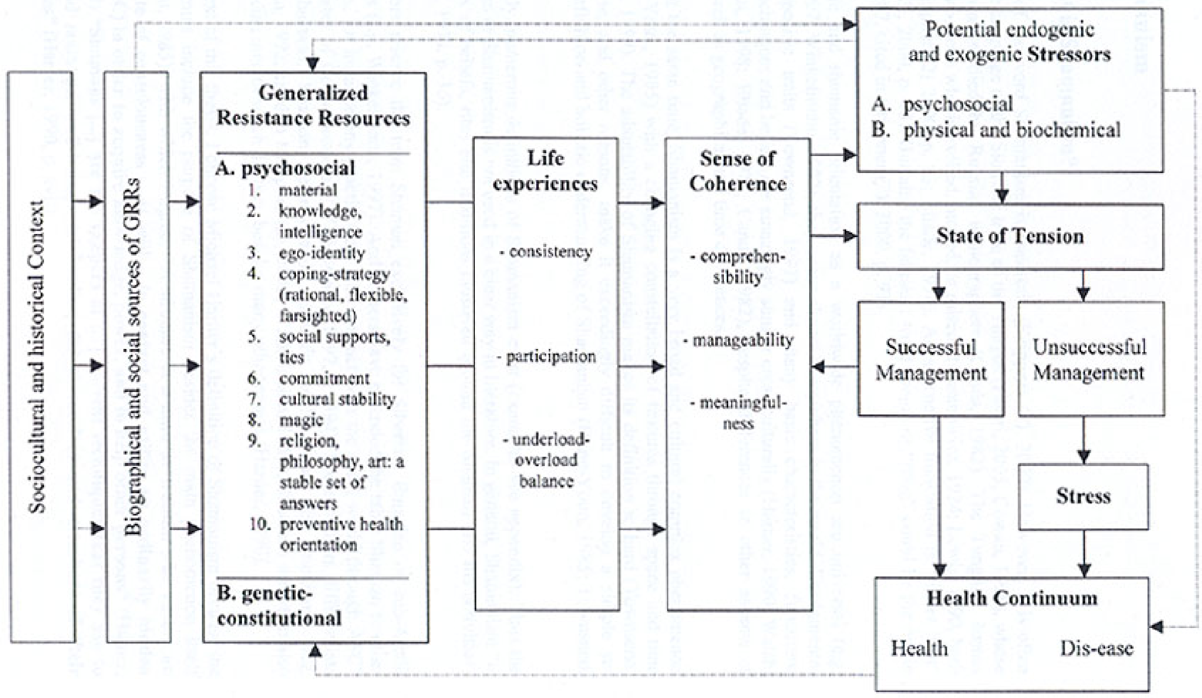

Figure 22: Model of salutogenesis according to Antonovsky (taken from Faltermaier, 2005, p. 66)

The negotiation process between stressors and resistance resources is conceptualized as the essential mechanism within the model. This negotiation process results in a state of tension with which the individual has to cope. Influenced by the interactions and feedback loops of the single dimensions (resources, stressors, sense of coherence, etc.), individual coping strategies are more or less successful and thus determine the individual's location on the health continuum (more towards health or more towards illness).

The following considerations and modifications are based on the framework offered by the salutogenesis model. Our aim was to develop a theoretical model for the analysis and interpretation of the biopsychosocial health trajectories of young competitive athletes assessed with the bioMAP program. The curves defined within this project (cf.

Chapter 2.4.1, Tab. 7) are at the core of our considerations. For the purpose of analysis, the curves can be assigned to the three concepts of the *health continuum, stressors, and resistance resources* within the salutogenetic model. Based on these considerations, we developed the following model (see Fig. 23).

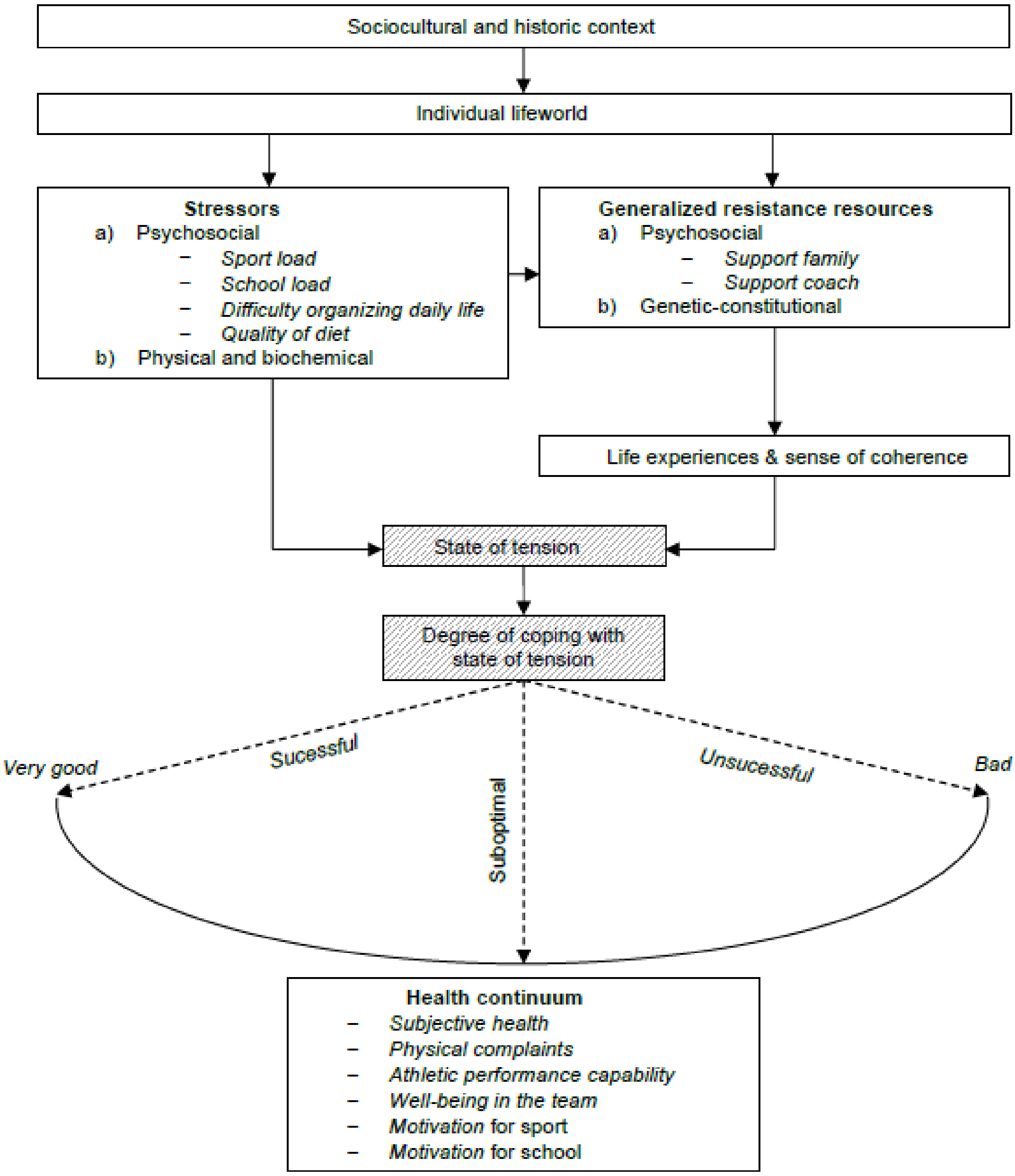

Figure 23: Modified salutogenesis model for the analysis of biographical mapping data

Competitive athletes operate in a socio-cultural context in which health is the central prerequisite for success. Accordingly, it is the goal of athletes to successfully overcome states of tension and to position themselves as far to the left on the health continuum as possible. Using the bioMAP method, it is now possible to identify the characteristics athletes exhibit in several biopsychosocial health indicators (subjective health, physical complaints, athletic performance capability, well-being in the team, motivation for sport, motivation for school) over a certain period of time. Furthermore, the general health situation can be assessed. The bioMAP method already uses an intensity scale (from 0 to 10) that allows to locate the health-related parameters on a continuum, which makes the method compatible with the salutogenesis model. The variables that we summarized under the health continuum basically correspond to a multidimensional understanding of health, which, following the underlying idea of the mapping method, is based on a subjective perspective.

In addition, information on the development of potential (psychosocial) stressors and resistance resources can be obtained from the curve courses defined in Chapter 2.4.1. In the context of elite sport, there is a multitude of possible stressors with which (especially young) athletes are confronted. These include mainly stressors in sports, school, and private life. Stressors can occur as a result of significant 'objective' (with regard to the life course) or subjectively relevant (with regard to the biography) life events. In the bioMAP, these data can be collected on the time axis (x-axis). When drawing the curves, the athletes interpret the recorded events with regard to their significance for the respective health-related parameter. Curves that represent the trajectory of potential stressors are the following: sport load, school load, difficulty of organizing daily life, and the quality of the diet. These stressors can be located at the psychosocial level.

Beside stressors, the resources that athletes have in their everyday lives and that support them when coping with stressors play an important role. These resources include the perceived support by the family and the perceived support by the coach. These variables, as well as the variables mentioned above, were determined based on the results of the expert workshops, and are located at the psychosocial level of resistance resources.

We have not yet explained the state of tension, which results from the interaction of stressors and resources, and the coping response. The state of tension itself and the corresponding coping response cannot be captured with pre-determined curve courses. Thus, they represent the black box of the presented model (depicted in grey in the model). Nevertheless, the data on the health continuum, the stressors, and the resources can provide meaningful information on the health status of athletes, offering starting points for individualized training and health management.

In the following, we present an analysis procedure based on the described model that allows a structured and theory-based interpretation of the bioMAP data.

3.3.2 Analysis and Interpretation in Four Steps

The modified salutogenesis model allows the stepwise analysis of data from the bioMAP assessment. Information on the development of the biopsychosocial health status of athletes can be obtained, which in turn is relevant for the individualized health and training management through coaches and caregivers. The procedure proposed in the following describes the individual steps of analysis. This is not yet a validated procedure. Rather, the four steps (as well as the proposed typification on the basis of the health indicators "subjective health", "physical complaints" and "athletic performance capability") were generated through an initial analysis of the data collected in the beta test and require further sound analyses in the long-term. Nevertheless, the proposed procedure offers a way to get familiar with the collected data material.

Step 1: Assess the development of health indicators

In order to organize and structure the initially confusing data material, it is proposed to first take a closer look at the development of the health indicators. However, even then, it is still necessary to further reduce complexity and not include all six variables (subjective health, physical complaints, athletic performance capability, well-being in the team, motivation for sport, and motivation for school). We recommend to first look at the three most global curves in order to further reduce complexity. In our opinion, in a sports system in which only "the efficient body" counts (Bette & Schimank, 1995, p. 44), these are the trajectories of the following variables: subjective health, physical complaints, and athletic performance capability.

On this basis, five exemplary 'health types' can be identified, taking into account relevant biographical events recorded on the time axis.

Type I: Moderate health restrictions

Athletes with moderate health restrictions barely miss any play time and report only very few (if any) health events (illness, injury, etc.). Overall, the curves show no extreme ups and downs and only moderate changes. If a higher curve deflection occurs, it appears punctually and briefly and can usually be attributed to a specific event. It is also noticeable that the curves "subjective health" and "athletic performance capability" run predominantly in parallel and in the upper third of the coordinate system. The "physical complaints" curve, on the other hand, is largely in the lower third, although the athletes almost never claim to be completely free of complaints. With regard to the curves "physical complaints" and "subjective health" there is almost no overlap and an increase in complaints is often only linked to sporting events (training camps, competitions etc.).

Type II: Successfully managed health crisis

For athletes assigned to the successfully managed health crisis type, the duration of the reported health events varies between one and four months. Overall, the curves are largely comparable with those of the previously defined type *moderate health restrictions*, but are characterized by a uniquely high severity of "physical complaints" with a simultaneous decrease in at least one of the two curves "subjective health" or "athletic performance capability". In most cases, an opposite course of physical complaints and subjective health/athletic performance capability can be observed. If physical complaints are indicated in a curve, these are usually linked to an illness or injury depicted on the time axis. Athletes of this type successfully coped with a health crisis. This can be observed with regard to the health indicator "physical complaints". After a period with increased complaints, a decline to a moderate level of complaints occurs. There is a slight tendency for the “subjective health” curve to decline even before the athlete's athletic performance capability drops, which means that the subjective health state is already lower in the run-up to a health event. In addition, overuse complaints (e.g. thigh or back problems) already become apparent in advance through a decline in the "subjective health" curve.

Type III: Acute health restrictions

Athletes with acute health restrictions tend to experience an increased degree of physical complaints at the time of the assessment. This type is characterized by an opposite development of the "subjective health" and "athletic performance capability" curves. In the run-up to the current situation, there are no clearly demarcated health-related events and with regard to the current curve characteristics, a clear event that would justify this deviation is not always apparent.

Type IV: Recurrent health restrictions

The type “recurrent health restrictions” is characterized by at least two phases with significantly increased levels of physical complaints (above medium level) and often a simultaneous reduction in the parameters "subjective health" and/or "athletic performance capability". If the athletic performance capability is reduced, usually the “subjective health” curve also shows reduced values. Both curves generally run contrary to the "physical complaints" curve. The deflections of all curves can usually be attributed to health events. Before and after a health event the curves return to the respective baseline level, which is different to the type “persistent/permanent health restriction” where this is not the case. The return to the baseline level is indicative of a good recovery after a health event. In particular, the parameters "subjective health" and "athletic performance capability" occasionally show time shifts in their trajectories, which are often linked to individual events and cannot be clearly explained.

Type V: Persistent/permanent health restrictions

Athletes with persistent/permanent health restrictions generally report many health events. Usually, they either report on one severe health event or a high number of minor health events with a high degree of complaint. In contrast to the type "recurrent health events", these physical complaints last for significantly longer periods of time and the values of the curves “subjective health” and “athletic performance capability” remain quite low. The curves have many ups and downs and barely remain at one level. Overall, all three curves ("subjective health", "physical complaints" and "athletic performance capability") are at a medium level. After a health event with a high level of symptoms, the values usually do not return to the initial pre-event level. This suggests that these athletes did not fully recover during the season. At times, the curves "physical complaints" and "subjective health" or "athletic performance capability" show an opposing development, whereby the curve "physical complaints" often runs above the other two curves.

Based on this first classification, the other health indicators ("well-being in the team", "motivation for sport" and "motivation for school") can also be considered. These can also be located on a continuum and can vary between very well or badly depending on the degree to which the state of tension is overcome (successful, suboptimal, or unsuccessful). It should be noted that inter-individual differences can also occur in this respect, depending on the individual's initial situation. Thus, for example, the social indicator "well-being in the team" can have constantly high values among athletes who have been part of the team for some time, whereas new team members mostly experience some changes in this parameter over the course of the season. In addition, the social well-being of athletes can also be affected by injuries if they feel that they cannot contribute to the team and sporting success due to an injury.

The health indicators "motivation for sport" and "motivation for school" can generally be traced back to biographical events. Motivation and commitment to sport are high when important sports events take place or when athletes experience a successful comeback after an injury induced break. The motivation for sport decreases when the athletic season comes to an end or during holidays. The motivation for school is usually higher when important exams or presentations are due or when the athlete cannot fully participate in training due to a previous injury. In contrast to the “motivation for sport” curve, the “motivation for school” curve experiences faster and deeper declines and tends to be less pronounced overall.

As already indicated in the description of the model in the previous subchapter, the location of the health indicators on the continuum is influenced by the degree of coping with the state of tension, which in turn arises from the complex interplay between the two dimensions "stressors" and "resources". In our model, the state of tension and the subsequent coping response represent the empirical black box and do not allow any conclusions to be drawn. However, information from the bioMAP can be used to derive statements on the characteristics of stressors and resources (for the assignment of the curves to the two dimensions, see Chapter 2.4.1, Table 7).

Step 2: Assess the progression of the stressor indicators

The psychosocial stressors that we assessed as part of the biographical mapping are "sport load", "school load", "difficulty of organizing daily life" and "quality of sport specific diet". The development of these stressors and their interaction with psychosocial resources might help explain certain health characteristics. Additionally, the experience of stressors can give the coach an idea about the athlete’s life circumstances and enables him or her to adjust and control the individual training load. If, for example, an athlete perceives an above-average level of sport load (e.g. in an inter-individual comparison), this could possibly be an indication of emerging health problems. In addition, a culmination of sporting, school, and/or private events can lead to excessive stress and thus influence the subjective health, athletic performance capability, physical complaints as well as motivation for school and sport.

Step 3: Assess the development of resource indicators

Psychosocial resources can help in coping productively with a higher degree of individual stressors. In our model, resources include the "perceived support from the family" and the "perceived support from the coach". Especially during difficult phases characterized by high stress, it is important for athletes to feel supported from their (direct) social environment. As far as family support is concerned, this rarely poses a problem. The perceived support from the coach is not always perceived as positive. This often seems to be linked to athletic performance and play time. Injured athletes who are unable to participate in team training and competitions or athletes who do not get much playing time due to a recovered injury may not feel supported by their coach.

Step 4: Assessing the overall situation and deriving intervention measures

Depending on the assessment of the overall situation, the curve courses can help identify two possible approaches for intervention. On the one hand, it is possible to infer measures directly from the curves if it is clear at which level of the model an intervention is necessary (i.e. at the level of stressors or resources). On the other hand, measures can also be inferred indirectly from the curves. In this regard, the curves offer first insights, which, however, must be augmented by additional tests. Here, questionnaires with validated scales (e.g. on personality, identity, burn-out, nutrition, etc.) or individual coach-athlete conversations can make a significant contribution.

At this point it should be emphasized once again that the proposed model and the analysis steps (especially with regard to the analysis of the individual curve courses) do not describe a validated procedure. Rather, they serve as a first orientation point clarifying the potential of the biographical mapping approach. Additionally, they help in structuring the data material. In the future, it will be necessary to collect more data and analyze it both qualitatively and quantitatively.

Finally, it can be summarized that the salutogenetic model provides a framework for interpretation that can be used both in practice and in research. The advantage of the theoretical framework lies in its potential to identify the reasons (at the level of psychosocial "stressors" and "resources") for positive or negative health-related developments. As it is the case with every model, the model is an abstraction with a simplifying perspective. Nevertheless, it takes the complexity of health-related developments into account by integrating the social context and subjective life experiences.

4 Conclusion and Outlook

With the conclusion of the service project *Development of an instrument for the retrospective analysis of biopsychosocial health trajectories of young elite athletes (bioMAP),* it can be stated that the goals set in advance were more than achieved. On the one hand, the bioMAP software was successfully developed and tested. Each of the three described project phases was characterized by an intensive mutual exchange with representatives from elite sports, which ensured a high level of acceptance of the software among coaches and athletes. In addition, we collected data during the field test of the beta version, which allowed an initial categorization of the mapping results after preliminary analyses (cf. chapter 3.3.2). The latter can support coaches in identifying typical health trajectories (moderate, acute, recurring, or persistent restrictions) and, if necessary, in deriving intervention measures.

From a scientific perspective, it will be necessary to analyze the collected data in more detail and to examine how the individual health-related trajectories interact with each other. The proposed four-step analysis procedure needs to be specified further; the categorized health types need to be differentiated further. An additional challenge when conducting studies with larger sample sizes is the development of further analytical methods that also allow a quantitative analysis. With the Excel export function, which also allows data transfer to the SPSS statistics program, an important foundation has already been laid. Finding analytical methods for the identification of typical patterns and trajectories has a high relevance. The integration of an alert function into the bioMAP software for critical or risky health trajectories would be of great help for coaches when designing training measures.

New application and analysis scenarios for elite sports practice have also emerged during the development of the bioMAP. For example, both athletes and coaches emphasize the need for an inter-individual comparison of health trajectories. So far, however, such a comparison can only be done by creating corresponding Excel tables, which is quite time consuming. In order to directly compare health trajectories between individuals, the bioMAP software should be augmented by a corresponding analysis feature. Such a function could also be used to compare the coach's subjective assessments (by drawing the progression curves for an athlete from the coach's perspective) with those of the athlete, and thus uncover possible discrepancies.

Also with regard to the frequency of application, further scenarios (in addition to those we have defined) should be considered. Athletes would prefer shorter intervals between the data collection points. Such a close monitoring could help identify critical developments even earlier, which would allow earlier intervention efforts. Additionally, athletes voiced the idea of a kind of “athlete’s diary”. Since the feedback on the method was almost entirely positive and almost all interviewed athletes stated that they were confident enough to complete a biographical mapping independently and without guidance, this represents an application scenario that has not yet been considered from a scientific perspective. Athletes are interested in reflecting critically on themselves and their careers, especially when they are confronted with road blocks and problems on their way to the top. However, it remains to be examined whether the bioMAP method has the same added value when completed by the athlete him- or herself as compared to an interview-based assessment.

The bioMAP software has proved to be an instrument that offers added value for both coaches and athletes and that allows a direct collection and analysis of data. The assessment is still relatively time-consuming and takes between 30 and 60 minutes, depending on the number of examined curves. Nevertheless, we expect that the biographical mapping approach with the bioMAP software has considerable potential for new and additional insights, particularly if used for extensive coach-athlete discussions. Especially when dealing with new athletes, coaches are able to collect a lot of information in a condensed form, which would otherwise only be detected slowly or not at all. bioMAP also supports young and less experienced coaches in the individualized design of training and health management strategies for young athletes.

An implementation of bioMAP into everyday training practice should be made possible in the near future. The prerequisites were created through the development and testing of the software, as well as through the close cooperation with our project partner, the VC Olympia Berlin. In the medium to long term, we can imagine that the software can be disseminated in other training contexts of the German Volleyball association, and also in other leading athletic associations as a best practice model. In order to achieve this, however, further research and development work in close contact with elite sports practice will be necessary.

5 References

Antonovsky, A. (1996). The salutogenetic model as a theory to guide health promotion. *Health Promotion International*, 11(1), 11-18.

Becker-Carus, C. & Wendt, M. (2017). *Motivation*. In C. Becker-Carus & M. Wendt (Eds.), Allgemeine Psychologie: Eine Einführung [General psychology: An introduction] (2nd edition, pp. 485-538). Berlin: Springer.

Bette, K. H. & Schimank, U. (1995). *Doping im Hochleistungssport: Anpassung durch Abweichung [Doping in elite level sports: Deviation as an adaptation]*. Frankfurt a.M.: Suhrkamp.

Faltermaier, T. (2005). *Gesundheitspsychologie [Health psychology]* (Volume 21). Stuttgart: Kohlhammer.

Frank, A. (1995). *The wounded storyteller: Body, illness and ethics*. Chicago: University of Chicago Press.

Gasser-Steiner, P. & Freidl, W. (1995). *Soziale Netzwerke und soziale Unterstützung [Social networks and social support]*. In O. Frischenschlager, M. Hexel, W. Kantner Rumpelmair, M. Ringler, W. Söllner & U. V. Wisiak (Eds.), Lehrbuch der Psychosozialen Medizin [Handbook of psychosocial medicine] (pp. 69-76). Wien: Springer Verlag.

Grechening, T., Bernhart, M., Breiteneder, R. & Kappel, K. (2010). *Softwaretechnik [Software technique]*. München: Pearson Studium.

Krause, A. (2003). *Lehrerbelastungsforschung: Erweiterung durch ein handlungspsycho-logisches Belastungskonzept [Research on teacher overload: Extension with an action-oriented, psychological load concept]*. *Zeitschrift für Pädagogik*, 49 (2), 254 273.

Lucas, R. E. & Diener, E. (2008). *Subjective well-being*. In M. Lewis, J. M. Haviland-Jones & L. Feldmann Barrett (Eds.), Handbook of emotions (3rd edition). New York: The Guilford Press.

Mayer, J. (2010). *Verletzungsmanagement im Spitzensport [Injury management in elite sport]* (Volume 203). Hamburg: Feldhaus, Czwalina.

Mittelmark, M. B. & Bull, T. (2013). The Salutogenetic Model of Health in Health Promotion Research. *Global Health Promotion*, 20(2), 30-38.

RKI. (2014). Faktenblatt zu GEDA 2012: Ergebnisse der Studie „Gesundheit in Deutschland aktuell 2012“ [Brief report on GEDA 2012: Findings from the study „Health in Germany 2012“]: Robert Koch Institut.

Sargirli, A. & Kausch, B. (2007). *Stichwort Leistungsfähigkeit [Search term performance capability]*. In K. Landau (Eds.), Lexikon Arbeitsgestaltung: Best Practice im Arbeitsprozess [Handbook on the design of work: Best vocational practice]. Wiesbaden: Alfons W. Gentner Verlag.

Schubring, A., Bub, E.-M. & Thiel, A. (2014). "How much is too much?" The social construction of elite youth athlete exercise tolerances from the coaches' perspective. *Journal of Sport and Social Issues,* 39(4), 308-331.

Schubring, A. & Thiel, A. (2014). Coping with growth in adolescent elite sport. *Sociology of Sport Journal*, 31, 304-326.

Thiel, A., Diehl, K., Giel, K., Schnell, A., Schubring, A., Mayer, J., et al. (2011). The German Young Olympic Athletes' Lifestyle and Health Management Study (GOAL Study): Design of a mixed-method study. *BMC Public Health,* 11(1), 410.

Thiel, A., Mayer, J. & Digel, H. (2010). *Gesundheit im Spitzensport: Eine sozialwissenschaftliche Analyse [Health in elite sport: A social scientific analysis]*. Schorndorf: Hofmann.

Thiel, A., Schubring, A., Schneider, S., Zipfel, S. & Mayer, J. (2015). Health in elite sports: A “bio-psycho-social” perspective. *Deutsche Zeitschrift für Sportmedizin*, 66 (9), 241-247.

Van Dick, R. & Stegmann, S. (2007). *Belastung, Beanspruchung und Stress im Lehrerberuf: Theorien und Modelle [Stress as a teacher: Theories and models]*. In M. Rothland (Ed.), Belastung und Beanspruchung im Lehrerberuf: Modelle, Befunde, Interventionen [Stress as a teacher: Models, findings, interventions] (1st edition, pp. 34-51). Wiesbaden: VS Verlag.