Providing Training Plans for Weight Training using CBR

Alexander Weber[1], Pascal Reuss[1,2], Jobst-Julius Bartels[1] and Klaus-Dieter Althoff[1,2]

[1]*Intelligent Information Systems Lab, University of Hildesheim*
[2]*Competence Center Case Based Reasoning, German Center for Artificial Intelligence, Kaiserslautern*

Abstract

Since several years the interest in fitness is increasing and therefore the demand for information about training plans has also increased. While fitness plan, especially training plans for weight training, can be created online with various tools, these plans usually are not tailored to the specific user, but mostly generic for certain purposes. This paper presents an application that uses Case-based Reasoning (CBR) to generate and adapt training plans for weight training based on basic user data, preferences, and restrictions. We describe the idea and goals for the application as well as the knowledge model for the CBR component including case structure and similarity measures. We also give an short overview of the current implementation and a first evaluation of the application.

Keywords

Case-based Reasoning, Case-based Planning, Fitness plans, Weight training

1. Introduction

The World Health Organization (WHO) names physical inactivity as one of the major causes for a decreased lifespan in developed countries on earth. Physical inactivity has negative impact on several diseases, for example diabetes[1]. The interest in fitness and the number of people performing physical activities to enhance and maintain their health is increasing during the last years. As a consequence of this increasing interest in fitness, the fitness industry itself is growing also. But despite this constant increase, a large number of people still maintain an nonathletic life style with insufficient physical activity[2]. The last two years with the COVID-19 pandemic have not supported the positive trending, because many physical activities like gyms were restricted and in many cases those missing activities are not replaced by other activities[3].

When someone decides to become active or more active in sports, they have a variety of digital resources available in different forms. The offerings range from paid models, such as Peloton, to free resources such as YouTube videos or free apps. Depending on the offer, the user gets access to personal advice or prefabricated plans, which are made available online. Sport is a very individual activity, where training plans are ideally tailored to the user and are performed with a coach to ensure that the exercises are performed correctly, especially in weight training. Many online resources, such as prefabricated training plans, offer little or no opportunities for

LWDA'22: Lernen, Wissen, Daten, Analysen. October 05–07, 2022, Hildesheim, Germany
reusspa@uni-hildesheim.de (P. Reuss); klaus-dieter.althoff@dfki.de (K. Althoff)

individualization and putting together training plans on its own is not a good option for many people due to lack of experience and time.

In order to counteract this problem, an application was developed that suggests training plans for users that fit their preferences and restrictions with the help of Case-based Reasoning (CBR). In this paper, we first take a look on some existing related work (Section 2) and then describe the basic idea and the goals of our application in Section 3. We also take a more detailed look on the knowledge modeling of our prototype in Section 3.1 and a short overview of the implementation in Section 3.2. The evaluation setup and the results are then discussed in Section 3.3. The paper ends with a conclusion and an outlook on future work.

2. Related work

Using CBR to suggest training plans is not a new idea. In recent years, a number of researchers have been working on this topic. One system was build to tailor training plans especially to obese people. It suggest plans, that were rated as efficient to loose weight by other people with similar characteristics. A case in this system contains information about the user like age, sex, weight, height and the body mass index (BMI). In addition, specific measurable blood values are stored, for example the values for cholesterol, glucose, and triglycerides. The blood values are more important for the similarity measurement than the basic physical values, therefore they have an higher weight.

Four types of training are available in the system: water training or swimming, concurrent training, where aerobics and strength training are performed in parallel, electrolypolysis, where fat zones are treated with tension and finally a combination of aerobic training and electrolypolysis. The duration of the training and observations during the training are also part of the solution of the case. In order to provide the experts who monitor the training sessions with all the necessary information, the cases also contain the measured values of the persons after the training, observations during the training and their consequences.

In the system, training plans based on user attributes are recommended in order to find the most efficient plan for a user. The system is heavily supervised by experts and has a very extensive data collection at the beginning, which is only possible with specialist staff. Part of the data is determined by a blood sample. This leads to well-comparable data, which are very specific for the purpose, in the case of weight loss, but as a consequence the system can not be used by users on their own[4].

Another system was designed to suggest training plans for exercises in gyms either with free weights or machines. It uses a combination of Rule-based Reasoning (RBR) and CBR and is designed for beginners in weight training. The problem structure contains information about the user itself as well as information about the muscles to be trained. The solution is the same fitness recommendation as for the most similar user if there is sufficient similarity. In the event that no sufficiently similar user is found, a second mechanism is applied, which aims to find an exercise that fits the user. The input will then be compared with an single exercise and not a complete training plan.

A case for an exercise has the same attributes as those that a user can specify. There is also an attribute that indicates the level of difficulty and is matched with the activity of the user, an attribute for sex, and an attribute that describes the necessary equipment. The necessary equipment and health complaints are not taken into account in the calculation of the similarity. In addition, the similarity measure uses the Sorsen-Dice coefficient[5] and therefore all attributes are equally weighted[6].

A third system uses CBR to generate training plans for marathon runners. Based on the previous training, the system makes predictions about the result of the marathon and can generate plans for any desired result of the marathon. Either a training plan based on a target time is searched or a target time based on the current training plan. Data from wearables such as the Applewatch is used to determine a runner's performance. For the system, individual training activities are tracked with data at 100 meter intervals. From these activities, the values for total distance, average speed, and both the fastest and slowest times for 10, 5 and 1km are read.

For a case, data is aggregated per week, with the number of activities and the longest distance being its own attributes. The speeds for the longest distance are also listed separately. For each week, the time distance to the planned marathon is relevant, as this determines the time period for possible training. For a given week, a case consists of the data of the current week including the data of the longest distance regardless of the current week and the current time of the person. For the person himself, only the sex, age and weight are used. sex is included as it has a big influence on training performance in the marathon. Since the amount of training has a big influence, a week always represents a case that is only compared to case from the same week.

When a future time is determined, a runner's data is entered in week X and the result is his weighted average time of k most similar runners. If the target is a training plan, the input consists of the training that the user has completed at the time and an adapted training time. We are looking for the most similar case of a user who has completed a marathon close to the new finish time[7].

In addition to these systems, other approaches for generating training plans can be found. Skreik an his colleagues developed a system based on automated plan generation with a planning domain definition language (PDDL). The system defines the current performance level of an athlete with the goal to bring the athlete to the best level of performance for him, regarding a given goal date. The starting level is the current state of an athlete, which is determined by dividing the body into upper, middle and lower body and these areas then again into biceps, triceps, deltoids, trapezius, lats, abdominal muscles, quadriceps, hamstrings, and calves. Maximum force, endurance and power are measured and recorded, as well as general tests for aerobic and anaerobic performance. The tests vary from exercises on a sports field to laboratory tests.

Different tests are made for each muscle group and the end result is an average of them, thus creating a good picture of the performance. These tests must be repeated regularly to ensure that the values develop as planned. In order to determine the actions that are needed, users must also indicate which aspect they would like to improve and how much they would like to do in which time frame[8].

All these systems are good approaches to generate training plans, but are limited in several ways, either by a specific group of users, a specific sport, or the effort for monitoring the progress. Our application is aimed at a broader scope for users in different training states and are training either in a gym or at home with machines, free weights, or only body weight. As a consequence, we have a broader case structure with more attributes and a broader knowledge base. The considered systems are a good inspiration for the required data, case structure, and similarity measures used in our system.

3. Weight training plans with CBR

The training application should be used by people who start with weight training or already have some knowledge and experience in weight training. And those people do not have an expert to aid them during their training. In addition, the application should support exercises with machines, free weights or body weight, performed in a gym or at home. Therefore, the application has to consider information about the users, their restrictions and preferences, the possible exercises, and the combination of exercises in training plans. We have identified six different use(r) cases for our application to cover:

1. A beginner in sports wants to start with weight training and needs a training plan for a whole body workout.
2. An active athlete in other sports that wants to start weight training as an addition.
3. An active athlete in weight training that wants to split his/her whole body workout into several training plans with muscle group focus.
4. An active athlete that wants to switch from gym workout to home workout.
5. A travelling athlete does not have access to the equipment, but does not want to neglect his workout.
6. An active athlete with progression problems wants a new different training plan.

The first and second use case deal with newcomers, while the other use cases deal with the support of people already in training. For those who are already active, it is assumed that people have a rough idea of fitness, but for whom a change of training plan is not trivial. For beginners, it is about helping them to provide a suitable training plan that allows them to achieve their goals efficiently and takes into account their possibilities. In addition, the time required to get started can be reduced. Both points can be served by generating complete training plans.

The third use case is about facilitating changes in training. This may be because the different muscle groups need to be trained more intensively or because there is less time available for training and the existing plan needs to be divided into several groups. The fourth and fifth use case deal with the support of an environment change, which can be temporary or indefinite. Whether a new plan is necessary for the change from the gym to the home workout, or whether only exercises need to be exchanged, depends on which plan the user already has and how much equipment he owns.

The last use case is about users who follow a training plan but are on a plateau, and these users can benefit from a completely new plan for the affected muscle groups, as this plan can provide different stimuli. Even if the reasons are different, all use cases need either to start a training plan or an adjustment that can be made depending on the extent of the changes made by a new plan or by exchanging exercises in an existing plan.

3.1. Knowledge modeling

Initially, the system has to be filled with a lot of plans and exercises as well as potential restrictions and preferences. The data about the exercises, plans, and restrictions of exercises has to be collected through experts. User restrictions and preferences have to be collected by user inputs. After the initial knowledge modeling, users can create and generate new plans for their workout. The experts can then evaluate these training plans and decide whether or not a new plan should be included in the knowledge base. An exercise or training plan that is not approved can still be used by the user who created it. In Figure 1 an overview of the modeled attributes can be seen.

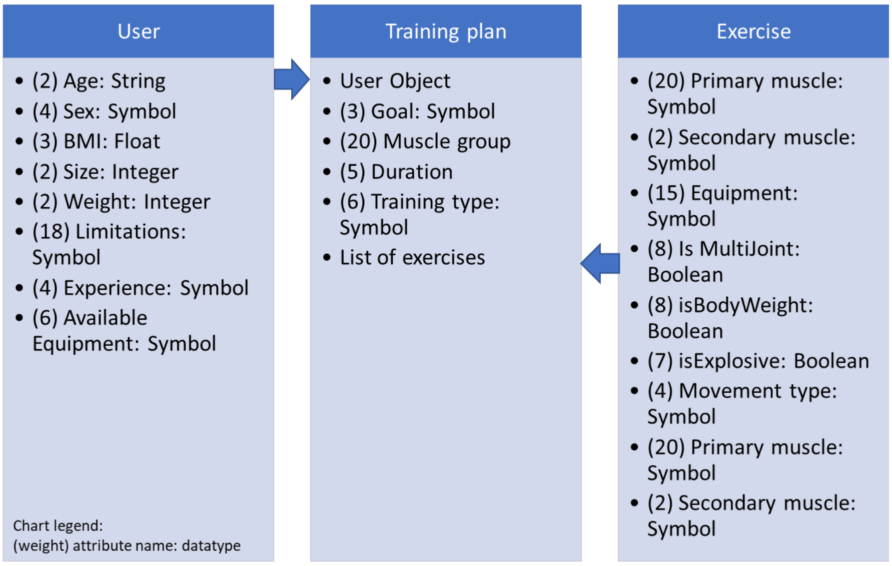

Figure 1: Attributes, data types, and weight of the knowledge model

3.1.1. Knowledge model for users

Attribute age: Based on the six use cases, the knowledge model has to consider information about potential users. The first relevant information in our context about a user is the age. The age influences a training in several ways. In addition to the performance, age also influences the choice of training, since the goals, especially before puberty, should be more focused on movements rather than on strength in order to provide a solid basis for later strength training. Especially in older age, the muscle strength of people decreases and thus the performance and, over time, the ability to perform certain activities. For older people strength training can lead to an improved quality of life, as it can counteract muscle loss and at the same time train the mobility of the body [9]. Also, the effects of training plans are influenced by age, which means that training plans should not be easily transferred to large age gaps, even if they are not pensioners, children or young people[10].

For the similarity of age, the relationship between age and performance was considered. This connection has been studied in the field of professional sports and different trends are emerging for the different sports. Although the endpoints differ, the courses themselves are very similar. In addition to athletic performance, mental performance, which can be influenced by age, is also evaluated. Even as a result of accidents or unhealthy lifestyles, people sometimes fail to reach their peak performance, but can improve their personal performance later in life by making changes[11][12][13]. In summary, a 10-year age difference should be more problematic in older age. This is because at the beginning of 20 the peak should be reached slowly and a plateau should follow, while at 40 the extraction is already stronger and the differences per year should be greater. The relative changes are not significantly different between the sexes, so it is not considered a factor. This results in a similarity function for age, which calculates a similarity of one up to a difference of two years, drops to 0.6 up to a difference of 5 years and drops to zero at 10 years.

Attribute experience: Another relevant information is the experience of the users. In order to recommend training plans to users that are able to perform the exercises safely and which are at the same time appropriate in scope, the user's experience must be determined. Without the information at all, there is a risk of suggesting exercises that a user cannot yet perform safely, even if they have guidance. For modeling purposes, a symbolic representation is used to map three groups of experience: beginner, advanced, and professional. The similarity is determined using a matrix, with beginner having some similarity to advanced athletes but no similarity to professionals. Advanced athletes have a higher similarity to professionals than to beginners.

Attribute sex: Another relevant information for training plans in weight training is the sex of the athletes. The sex of a person is about the physical differences in the physique of men and women. It has been shown that the maximum strength, measured by knee extensions, that men and women can exert is very different in adulthood and only converges with increasing age, as the musculature of women degrades less[11]. In addition, there are differences in overall muscle mass and especially in muscle mass in the upper body[14]. For the representation of gender, a symbolic representation was chosen. Male, female or diverse are offered as possible values to give as many people as possible a choice. While sports research often only differentiates between male and female and there are relevant differences, people who feel they were born in the wrong body are also on the spectrum between male and female. In the course of hormone therapy, some characteristics relevant to sports would also adapt, making the value divers meaningful[15]. For the similarity measure, it is assumed that a person who chooses divers is someone who adjusts his gender to his self-perception through therapy and thus is of the physical condition between the sexes. There is a simplifying assumption that there is a linear change in the relevant characteristics, therefore diverse has a 50 percent similarity to both male and female. This assumption will not apply to all users and people will also choose diverse who may not be doing therapy.

Attribute weight: The body weight of a person influences the performance that can be achieved during exercises. It can be composed of different parts of muscle mass and body fat and has a different influence depending on this, so the weight must be put in context with the sporting activity of a person. For body weight exercises, a high body weight can be a problem because the muscles and joints are subjected to a higher load and therefore the number of repetitions is lower than for people with less body weight. The similarity for the body weight is calculated via an integer function with a linear descent of the curve until a difference of 50 kilogram is reached.

Attribute size: Under certain circumstances, body size may also be relevant for the creation of a training plan. Not all equipment is adjustable for all heights and therefore usable. The taller person also has a different lever for some exercises, making the repetitions for the same weight harder for the taller person. This is especially true for body weight exercises, as a smaller person will have less weight on the forearms for push-ups, for example, even though the two people weigh almost the same. Due to the rather small influence of height on the design of the training plan, a distance of 50 cm is set based on the size distribution in Germany[16], at which height still has a similarity of 0.5. From that point on, the similarity decreases more and reaches zero at a difference of 80 cm or more.

Attribute limitations: Two other information groups are relevant from the athletes perspective: the limitations or restrictions and the available equipment. An example of limitations is the limited load-bearing capacity of joints, which means that certain exercises cannot be performed because they cause more damage than they help. But diseases can also have an impact on exercise selection and performance. In the context of the app, we will look at ailments that directly relate to exercise selection in a training plan or otherwise have easily understood influences on the acute variables of a training plan: Shoulder, upper spine, lower spine, elbows, knees, ankles and wrists, hip joints. In addition, two medical conditions where the influence on weight training are documented: Diabetes[17] and Heart Disease[18].

Attribute available equipment Equipment or devices represent another attribute of a user, they describe the options they have for performing exercises. With the help of this attribute, a training plan can be better tailored to a user, as it can take advantage of the user's options to achieve an efficient result. At the same time, the attribute can help the system not to suggest training plans to the user that do not fit the user because the user does not have the necessary equipment. The range of values includes dumbbells and barbells, pull-up bar, kettle bells, dip bars, thera-bands, weight bench, gym, and no equipment.

In addition to the user, the training plans and exercises must also be modeled. A training plan is composed of a set of exercises and always pursues a goal, for a desired muscle group. The exercises in a training plan determine how long it lasts and what equipment is needed for it.

3.1.2. Knowledge model for training plans

Attribute goal: A training plan is described by three primary attributes and a list of exercises. The primary attributes are the goal of the training plan, the muscle group(s) to be trained, the duration to absolve all exercises of a plan, and the weight volume. A training plan needs a goal to be effective[19]. In our context, four goals were defined for strength training: Power, maximum strength, strength endurance and muscle mass. The similarity of the targets is defined in a similarity matrix, where the three targets maximum strength, muscle endurance and muscle mass still have similarities of 0.6 among themselves while power is not similar to the other targets. The reason for this is that the first three goals can be rearranged quite well by adaptation. For the first three goals, the same or very similar exercises can be used, with different sets, repetitions, rests and weights, while a training plan for Power consists largely of specific exercises.

Attribute muscle group: Another attribute that is needed is the muscle group that the training plan should train. Since not all training plans should address all muscle groups, so that less time needs to be invested per workout or only certain aspects of the body should be trained, it must be clear which areas a training plan should address. The muscle groups are also shown as symbols. For the subdivision of the muscle groups, the individual areas are considered, which can be trained and combined with split training[9][20]. A total of nine muscle groups have been defined: arms, chest, abdomen, legs, back, shoulders, upper body, lower body, full body. A similarity matrix is used to calculate the similarity. Since the muscle groups cannot be adapted by adaptation, since this would require exchanging exercises for other exercises that are not similar to them, only matches are considered here.

Attribute duration: Each plan has a certain duration needed to complete it. The time, for a given plan, may vary somewhat between two people. This is due to the fact that the duration of a repetition of an exercise is not always exact or the planned breaks are not followed correctly. The attribute is very important because the potential user of the app has a limited time budget for which he is looking for a training plan. The duration is specified as an integer in seconds. For the duration similarity, a maximum difference of 15 minutes is considered, above which the similarity is zero. The similarity decreases linearly for the function until it reaches zero. The maximum difference of 15 minutes is based on the assumption that one exercise unit lasts about 5 minutes and thus a maximum of three exercises more or less are included in the training plan.

Attribute training type: A training plan is applicable for a certain type of training. We modeled three training types: upper body training, lower body training, and whole body training. This way, the training plans for a specific desired training can be retrieved.

Attribute exercises: The last attribute of the training plan is a list of exercises. In order for the application to exchange exercises, the exercises must be mapped as completely as possible to ensure that the efficiency of a training plan suffers as little as possible.

3.1.3. Knowledge model for exercises

Attribute primary muscle group: An exercise is represented by seven attributes. One attribute is the primary loaded muscle, which is primarily relevant for the exchange of exercises. Like the muscle groups, these muscles are also shown as symbols, but in more detail than the muscle groups. A total of 15 different muscles are distinguished in the attribute values: biceps, triceps, forearms, chest, straight and lateral abs, anterior and posterior shoulders, calves, anterior and posterior thighs, gluteus, as well as lower, middle and upper back. The similarity measure of the attribute is modeled as for the muscle groups. For an exercise to be considered similar, the primary muscle has to match.

Attribute secondary muscle group: In addition to a primary loaded muscle, many exercises also have another loaded muscle that is trained as a side effect. Thereby it is again relevant for the exchange, even if to a lesser degree. It is possible that the secondary muscle is noticeably co-trained or that there is no good separation between primary and secondary muscle. The values are the same as for the attribute for the primary muscle with an additional value if no secondary muscle is used. Unlike the primary muscle, a deviation in the secondary muscle is less bad and may even be desired to achieve a different type of exercise for the primary muscle. Therefore, the similarity measure can be more differentiated for this attribute.

Attribute equipment: Each exercise needs an assigned piece of equipment so that the list of equipment for a training plan can be recognized based on the exercises used. The equipment is also needed so that when an exercise is replaced, it can be noted whether a user can perform a particular exercise at all. For similarity, only an exact match is considered. The exception is the equipment gym, as this attribute combines several pieces of equipment. Therefore, a gym has a similarity of one to all items that are assumed to be in a gym.

Attribute body weight exercise: In order for the system to be appropriately extended for body weight exercises, an attribute is defined to record whether an exercise is body weight exercise. Since the attribute has only two values, it is represented as a Boolean.

Attribute used joints: Exercises can be divided into two categories, multi-joint and single-joint, which describe how many joints an exercise uses. Since multi-joint exercises involve a majority of muscles, they are usually more complicated to perform, but allow for greater weights to be moved and thus offer an advantage for strength training. In comparison, single-joint exercises are easier to perform and isolate a specific muscle, making them more interesting for beginners. Since these types of exercises fulfill different roles in the context of the training plan, it is important for swapping an exercise to maintain its characteristic. Only two types are distinguished, so a Boolean is sufficient for representation[19][9].

Attribute muscle movement: Another relevant property for an exercise is the muscle movement that is performed. This also has an influence on the effect that the training has on a muscle, so this property should also be maintained. The three types of muscle movement are not particularly important when creating a training plan, as this point has usually been taken care of by the exercise selection. If an exercise should be replaced from a plan, it should be replaced by an exercise that has the same movement characteristics[20]. Three movements are distinguished: push, pull, and isometric. Due to the different nature of the exercises, which have different muscle movements, no similarities are established between them.

Attribute explosive movement: There are exercises that involve explosive movements, these are mostly exercises for improving power. The exercises are rarely just, faster executed versions of the otherwise also used exercises. For power training, more specially designed exercises are used[9]. In order to avoid exchanging a power exercise with a normal exercise for a muscle group, this attribute is used to distinguish between these types of exercises.

3.1.4. Case structures

Based on the required attributes, two case structures are modeled: a case structure for the training plans and one case structure for exercises. The structure for training plans contains the attributes for the user and the training plan as a problem description and a list of exercises as the solution. The structure for the exercises contains the described attributes as the problem description and another exercise as the solution.

3.2. Implementation

The prototypical application was implemented as a client-server-structure with a smartphone app as the client and the CBR system as the server. As a tool for building the CBR system, our open access tool myCBR [21][22] was used. The application currently supports the retrieve and reuse steps of the CBR cycle [23].

When a user creates a training plan, the CBR component attempts to determine the appropriate intensity by searching the training plans of similar users for exercises that train the same muscles with the same goal. After the similar users are determined, their training plans are loaded that have the same goal as the training plan that was created. For each exercise, the training plans are searched for all exercises that train the same primary muscle and match the specified equipment. The exercises that do not match in the most similar training plan can thus be replaced. If a user wants to further customize their generated training plan, they can manually replace exercises by editing the entire training plan or they can get suggestions by retrieving a list of individual exercises that can be integrated in the training plan. The exercises itself are not adapted during the reuse step, but the training plans by using case-based adaption of exercises. The current implementation of the app can be found on Github: https://github.com/FitnessCBR/FitnessCBR.git

3.3. Evaluation

The evaluation of the prototypical system was somewhat challenging, because during the COVID-19 pandemic the physical activity of many people was reduced and therefore finding people performing the suggested training plans was not easy. We conducted an expert evaluation of the generated training plans and the replacement of exercises. Two expert fitness trainers queried training plans with the app and analyzed them. The fitness trainers has been working for 6 respective 9 years for the company RSG Group which has been operating since 1996 and has as its core business the operation of fitness studios. The company now owns many well-known fitness brands such as Gold's Gym, McFit and Cyberobics. Together, more than 6 million members can be recorded in studios and digital offers. Both trainers have a licence class B for fitness training. Each trainer queried the CBR system ten times with different user and training plan characteristics. At first the retrieved plans were evaluated as a whole and in a second step, specific exercises were selected for exchange and the new exercises were evaluated in context of the training plan. The fitness experts rated the training plans and exercises on a scale from 1 to 5, where 1 means a perfect match and 5 a totally unsuitable plan or exercise. Table 1 shows the results of the evaluation.

The evaluation results show, that the system is capable of retrieving good training plans, but not every time a perfect match. But a perfect match is also dependent of the context and perspective of the user. The training plans for power training do not fit very well, but the feedback from the trainers suggest, that the system contains to few exercises for power training. The exchange of exercises works also good, but for a better match not only the replaced exercise should be considered but the other exercises in the plan and the order of the exercises, too. Because the order of an exercise in the training plan has an impact of difficulty of an exercise that should be suggested. Overall all training plans followed established rules and contain no surprising exercises or combinations.

Table 1
Evaluation results of the training plans and exercises by experts (E1/E2)

Training plan	result(E1/E2)	exchanged exercises	result(E1/E2)
max strength	2/2	chest	2/3
max strength	2/2	shoulder	3/3
max strength	3/2	shoulder	3/4
power	4/4	biceps	3/3
power	3/4	legs	2/3
strength endurance	1/2	triceps	2/2
strength endurance	2/2	chest	2/2
strength endurance	2/1	legs	2/1
muscle mass	2/2	chest	2/3
muscle mass	2/3	biceps	2/2

4. Conclusion and outlook

In this paper we present an application for the generation and suggestion of training plans for weight training in different use cases. We describe the motivation behind it and take a detailed look on the knowledge model and the decisions behind it. We also give an short overview of the current prototype and the first evaluation with fitness experts.

Given the current state and the results of the evaluation, we plan to extend the knowledge model with some additional attributes like the number of sets for exercises and the order of exercises in the training plan. The retrieval process for exercises to be exchange will also be reworked to consider the context of the exercise in the training plan. An extended evaluation is also undergoing with the current version of the prototype by working with a number of non-expert athletes to evaluate the training plans. This evaluation will be repeated with the enhanced prototype.

References

[1] W. H. Organization, Physical activity: Key facts, 2020. URL: https://www.who.int/news-room/fact-sheets/detail/physical-activity.

[2] A. Batrakoulis, European survey of fitness trends for 2020, ACSM s Health & Fitness Journal 23 (2019) 28–35.

[3] T. Peçanha, K. F. Goessler, H. Roschel, B. Gualano, Social isolation during the covid-19 pandemic can increase physical inactivity and the global burden of cardiovascular disease, American journal of physiology. Heart and circulatory physiology 318 (2020) H1441—H1446.

[4] F. Lorenzi, R. Rosa, A. Peres, G. Dorneles, A. Peres, F. Ricci, Tailoring training for obese individuals with case-based reasoning, in: Proceedings of the 8th ACM International Conference, 2017, pp. 142–147.

[5] T. J. Sorensen, A method of establishing groups of equal amplitude in plant sociology on similarity of species content and its application to analyses of the vegetation on Danish commons, I kommission hos E. Munksgaard, Kobenhavn, 1948.

[6] D. Salim, N. Perdana, B. Mulyawan, Application of the case based reasoning & sorensen-dice

coefficient method for fitness exercise program, IOP Conference Series: Materials Science and Engineering 1007 (2020) 012188.
[7] C. Feely, B. Caulfield, A. Lawlor, B. Smyth, Using case-based reasoning to predict marathon performance and recommend tailored training plans, in: Case-based Reasoning Research and Development, 2020, pp. 67–81.
[8] T. Skerik, L. Chrpa, W. Faber, M. Vallati, Automated training plan generation for athletes, in: Proceedings of the 2018 IEEE International Conference on Systems, Man, and Cybernetics, 2018, pp. 3865–3870.
[9] L. Brown, N. S. . C. A. (U.S.), Strength Training, Human Kinetics, 2007. URL: https://books.google.de/books?id=SOjE7VQ2iWkC.
[10] W. Sands, J. Wurth, J. Hewit, NSCA: Basic of strength and conditioning manual, National Strength and Conditioning Association, 2012.
[11] R. Lindle, E. Metter, N. Lynch, J. Fleg, J. Fozard, J. Tobin, T. Roy, B. Hurley, Age and gender comparisons of muscle strength in 654 women and men aged 20–93 yr, Journal of applied physiology (Bethesda, Md. : 1985) 83 (1997) 1581–7.
[12] M. Huebner, D. Meltzer, A. Perperoglou, Age-associated performance decline and sex differences in olympic weightlifting, Medicine and science in sports and exercise 51 (2019).
[13] G. Berthelot, S. Johnson, P. Noirez, J. Antero-Jacquemin, A. Marck, F.-D. Desgorces, F. Pifferi, P. Carter, M. Spedding, A. Singh-Manoux, J.-F. Toussaint, The age-performance relationship in the general population and strategies to delay age related decline in performance, Archives of Public Health 77 (2019) 51.
[14] J. Harrison, Bodyweight training: A return to basics, Strength & Conditioning Journal 32 (2010) 52–55.
[15] J. Harper, E. O'Donnell, B. Khorashad, H. McDermott, G. Witcomb, How does hormone transition in transgender women change body composition, muscle strength and haemoglobin? systematic review with a focus on the implications for sport participation, British journal of sports medicine 55 (2021).
[16] S. R. Department, Survey about body size in germany, 2021. URL: https://de.statista.com/statistik/daten/studie/278035/umfrage/koerpergroesse-in-deutschland/.
[17] M. Hordern, D. Dunstan, J. Prins, M. Baker, M. fiatarone singh, J. Coombes, Exercise prescription for patients with type 2 diabetes and pre-diabetes: A position statement from exercise and sport science australia, Journal of science and medicine in sport / Sports Medicine Australia 15 (2011) 25–31.
[18] N. Meka, S. Katragadda, B. Cherian, R. Arora, Review: Endurance exercise and resistance training in cardiovascular disease, Therapeutic advances in cardiovascular disease 2 (2008) 115–21.
[19] S. Bird, K. Tarpenning, F. Marino, Designing resistance training programmes to enhance muscular fitness: A review of the acute programme variables, Sports Medicine 35 (2005) 841–51.
[20] W. Kraemer, N. Ratamess, Fundamentals of resistance training: Progression and exercise prescription, Medicine and science in sports and exercise 36 (2004) 674–88.
[21] K. Bach, K.-D. Althoff, Developing case-based reasoning applications using mycbr 3, in: Proceedings of the 20th International Conference on Case-based Reasoning 2012, Springer, 2012, pp. 17–31.
[22] A. Hundt, P. Reuss, C. S. Sauer, T. Roth-Berhofer, Knowledge modeling and maintenance in mycbr 3, in: Proceedings of the FGWM workshop at Learning, Knowledge, Adaptation conference 2014, Springer, 2014.
[23] A. Aamodt, E. Plaza, Case-based reasoning: Foundational issues, methodological variations and system approaches, AI Communications 7 (1994) 39–59. URL: http://www.idi.ntnu.no/emner/it3794/lectures/papers/Aamodt_1994_Case.pdf.