Factors Influencing Food Choices in Different Sports: Importance of Sustainability, Performance and Health: A Cross-Sectional Study

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Abstract

Background: This study investigates food preferences among individuals active in different sports. Since food intake affects the carbon footprint, it is of interest to investigate influencing factors of food choices regarding sustainability. Physically active individuals are in need for high intakes of energy and protein in order to maintain their performance. Little is known about what influence food choices in this population.

Method: A survey of a sample of 367 individuals was conducted in German and Swedish gyms, climbing halls and CrossFit boxes. Therefore, a questionnaire was developed to capture information about factors influencing food choice and consumed protein sources. Kruskal-Wallis-test tested significant differences between sport groups and physical activity levels.

Results: The most frequently consumed animal-based protein were dairy-products, and the most frequently used plant-based source were grains. Taste and health were the main influences on food choices. Significant differences were observed between sport groups and physical activity levels. Sustainability was ranked as moderately important, with the highest importance in people active in the outdoor sports running and climbing. Participants with high physical activity levels and active in CrossFit rated performance more important than the rest of the sample and consumed protein supplements, eggs and poultry more frequently.

Conclusion: Differences in food choices between various sports and physical activity levels were identified. Understanding the underlying influences on food choices might help to motivate a shift towards a more sustainable diet in athletes.

1. Introduction

Food choices among consumers have an impact on the total climate carbon footprint from food consumption. Estimates indicate that food chains, including food production, -distribution, and -consumption, contribute with 25% up to 30% of global greenhouse-gas emissions (GHGE)(1)(1,2). A change in dietary habits as a reduction of animal-based foods and an increase of plant-based foods is often considered one of the most effective strategies for systematically reducing GHGEs related to food production and consumption (3).

Regarding macronutrients, animal products are often consumed due to their high protein content. It is assumed that athletes and physically active individuals are one target group in need of a higher quantity of protein than non-active, sedentary individuals (4). Physically active individuals can find specific protein recommendations, varying from 1.4 to 2.0 g of protein per kg of bodyweight per day, to optimize exercise training induced metabolic adaptations, e.g., building and maintaining muscle mass (5,6).

Since food choices have an impact on GHGE and the choice of different protein sources leads to a different impact on the carbon footprint, it is of interest what influences the food choices of individuals regarding sustainability. Former studies identified performance related motives as the most important

influence on food choices in athletes (7–10). Performance was most of the time interrelated with food that promotes health (8,10). Nevertheless, literature addressing sustainability as a potential underlying motive for food choices in physically active individuals is lacking. This study wants to explore, if sustainability is an influencing factor on food choices. What kind of protein sources are consumed in physically active individuals and in which amounts? Another aspect of interest is identifying possible distinctions in food choices between different types of sport and physical activity levels.

2. Materials And Methods

2.1 Design and procedure

To survey a more specific target group, this study included physically active individuals between 18 and 40 years old. Data was collected in Germany and Sweden in February 2020. Since differences in food choices between a variety of types of sports was one point of interest, data collection took place at different sport facilities. The authors chose Climbing and CrossFit facilities to be able to compare outdoor sports with a sport characterized by high intensity strength training, which often aims for an increase in muscle mass. Therefore, climbing halls and CrossFit-boxes were selected as recruitment settings. The questionnaires were furthermore handed out at Gym training centres to target a broader range of physically active people. The questionnaires were handed out personally by the author.

Participants were selected and addressed in the entrance and resting area of each facility. In addition, CrossFit- and Climbing groups were invited to fill in an online survey through the trainers of those groups. The online survey, containing the same questions as in paper form, was conducted via an online survey platform (www.soscisurvey.de). The study followed ethical rules and when invited, the participants were informed about the purpose of the study, that participation was optional and that the collected data was anonymous.

2.2 Study population

In total, 380 surveys, paper or online, were filled out. In Germany, 215 questionnaires (136 online surveys, 79 printed questionnaires) and 165 in Sweden (51 via online survey, 114 printed) were answered. From 478 clicks on the link, 184 online surveys were filled out completely (38%). Only individuals who did not fill out the paper form were asked to take the online survey. In the printed form, all 193 handed out questionnaires were filled out, resulting in a total response rate of 56.6%. 13 cases of individuals older than 40 years were excluded. In the end, data from 367 different surveys were used for the statistical analysis. A summary is shown in the flow-diagram in Fig. 1. 55.3% (n = 203) participants were currently living in Germany, 44.7% (n = 164) in Sweden. The study population consisted of 48% (n = 176) female and 52% (n = 191) male participants. The participants' age range was between 18 and 40 years with a mean value of 28.3 years. A summary of sociodemographic data of the participants is shown in Table 1.

Table 1
Characteristics of the participants (n = amount of data used for analysis).

Socio-demographics	Mean (SD)	[range]
Age in years	28.3 ($\pm$ 4.6)	[18–40]
Bodyweight in kg	70.4 ($\pm$ 12.1)	[46–110]
Body height in cm	174.6 ($\pm$ 9.4)	[146–201]
BMI	22.97 ($\pm$ 2.62)	[17.01–31.46]
<i>Females</i>	22.03 ($\pm$ 2.57)	[17.01–31.46]
<i>Males</i>	23.83 ($\pm$ 2.37)	[17.34–30.47]
n (%)		
Gender		
Female	176 (48)	
Male	191 (52)	
Country		
Germany	203 (55.3)	
Sweden	164 (44.7)	

2.3 Questionnaire

For the assessment of influences on food choices and for getting additional information about consumed protein sources, a questionnaire was developed based on the Food Choice Questionnaire (FCQ, Steptoe et al., (1995)) and the Athlete Food Choice Questionnaire implemented 2019 by Thurecht & Pelly (2019). From these questionnaires, only specific items were chosen. The questionnaire contained 26 different items that were segmented in 12 different dimensions. The following dimensions were included: sustainability, performance, price, convenience, familiarity, availability, weight control, influence of others, natural content, health, nutritional attributes and sensory appeal. To depict the dimension of sustainability in more depth, this factor includes besides the items of *environmentally friendly packaging* and *label of country of origin* additionally the items of *organic food*, *sustainable production* and *comes from nearby regions*. The participants were able to choose their tendencies on each item on a four-point Likert scale, namely from *not important at all*, *little important*, *moderately important* and *very important*. In total, the questionnaire consisted of 16 questions and was developed in English. In addition to the factors that influence the choice of food, the questionnaire included the frequency of consuming different protein sources. Demographic questions included age, gender, country, highest level of education and what kind of physical activity the person was most active in. The face validity of this conducted questionnaire was internally tested and evaluated beforehand by 15 people.

2.4 Data Processing and Statistical Analysis

The response options to the questions of the filled-out questionnaires and the online survey were coded in numerical values (1–4 for the dimensions of importance of FCQ-items, 1–6 for frequency of consumed protein sources) to be able to calculate and compare the values of each sample with another. Descriptive statistics included frequencies and percentages for categorical variables, mean and standard deviation for continuous variables. As central tendency for non-continuous variables, the median was calculated. Normal distribution of the data was tested by the Kolmogorov-Smirnov-test and Shapiro-Wilk-test. For further analysis, non-parametric tests for not normally distributed and ordinal data were used. The Mann-Whitney u-test for comparing two mean ranks of variables was conducted to identify differences in distributions of the two samples. In this case, protein sources and FCQ-items between Germany and Sweden were tested. In order to test for differences in the distributions with more than two variables, the Kruskal Wallis test was carried out. For a pairwise comparison, the Dunn Bonferroni post-hoc test was applied. The Kruskal Wallis test, which calculates with mean ranks of variables, was conducted to compare the influences on food choices and consumed protein sources in different sports and different physical activity levels. The threshold of statistical significance was set to a p-level of 0.05. Analysis was conducted with IBM SPSS Statistics 26.0 (IBM Inc., Armonk, NY, USA, 2019).

3. Results

The most often mentioned sports in the answers of the questionnaire were Climbing 37.3% (n = 137), CrossFit 22.9% (n = 84), Gym training 16.9% (n = 62) and Running 12.5% (n = 46). The largest percentage of the study population were physically active on a vigorous level of 3–5 hours per week 25.9% (n = 95). Most important ranked were the items of keeps me healthy where 53.7% ranked as very important, only 2.2% as not important at all, and tastes good where 62.1% ranked as very important, 0.5% ranked as not important at all, Table 2.

Table 2

Frequencies of the ranking of the FCQ-items related to Sustainability, Performance and Health. N = 367

FCQ- items	Very important % (n)	Moderately important % (n)	A little important % (n)	Not important at all % (n)
Sustainability				
Has the country of origin clearly labelled	24.3 (89)	32.4 (119)	28.3 (104)	15.0 (55)
Comes from nearby regions	22.6 (83)	45.8 (168)	26.2 (96)	5.4 (20)
Is packaged in an environmentally friendly way	22.6 (83)	42.8 (157)	26.7 (98)	7.9 (29)
Is sustainably produced	21.8 (80)	41.7 (153)	32.4 (119)	4.1 (15)
Is organic	18.8 (69)	38.4 (141)	32.4 (119)	10.4 (38)
Performance				
Fuels my body for training	34.1 (125)	34.6 (127)	19.6 (72)	11.7 (43)
Makes me feel energetic for training/competition	27.5 (101)	38.7 (142)	23.7 (87)	10.1 (37)
Helps my body with recovery after training	27.5 (101)	33.0 (121)	23.4 (86)	16.1 (59)
Is high in protein	7.1 (26)	35.1 (129)	36.2 (133)	21.5 (79)
Health				
Keeps me healthy	53.7 (197)	38.1 (140)	6.0 (22)	2.2 (8)
Contains natural ingredients	42.5 (156)	40.6 (149)	14.4 (53)	2.5 (9)

A third, 31% (n = 114) of the total sample ranked the items related to sustainability (Is packaged in an environmentally friendly way, comes from nearby regions, is organic, is sustainably produced, has the country of origin clearly labelled) moderately important or very important. Also, a third, 32% (n = 119) of the total sample ranked all items in the performance factor (Is high in protein, fuels my body for training, makes me feel energetic for training/competition and helps my body with recovery) as one of the two highest rankings of importance, namely either moderately important or very important. Besides the frequencies and percentages of each item ranking of the total sample, the rankings of the individual sports were also one aspect of interest. Regarding sustainability, the highest percentages in one sport group were 41.3% (n = 19) in people active in Running and 37.2% (n = 51) in Climbing. Those performing CrossFit had the least percentages in sustainability section, 21.4% (n = 18). In addition, 71.4% (n = 60) of people active in CrossFit ranked all items in performance either moderately important or very important. People active in CrossFit ranked all of the four items more important than people active in other types of

sports. In the group of Climbers, the higher importance ranking of performance was 22.6% (n = 31). Difference in rankings of the FCQ-items related to sustainability between the different types of sports are shown in Fig. 2. The ranking of items relating to performance in different sports are presented in Fig. 3. The significance levels of group comparison between CrossFit and other sports are shown in Table 3.

Concerning the factor of sustainability, the Kruskal-Wallis-test identified significant differences in the mean ranks between the different sports. People active in Running had the highest mean ranks for sustainability while active in CrossFit had the lowest. All four items for the factor of performance showed distribution differences between different sports ($p < 0.001$). The post-hoc analysis with pairwise comparison identified people active in CrossFit having the highest mean ranks. Table 3 outlines the test results for every item of the FCQ.

Comparing the results of the test to the frequencies of the FCQ items among the different sports (Figs. 2 and 3), items related to performance were ranked more important in people active in CrossFit compared to the other sports.

Table 3
Comparison of main sports and ranking of Food Choice Questionnaire items.

Food Choice Questionnaire items	Kruskal-Wallis H	Asymp. Sign.	Post-hoc analysis* p-value ≤ 0.05
Sustainability			
Is packaged in an environmentally friendly way	12.859	.012	CrossFit vs. Running .017
Comes from nearby regions	12.228	.016	CrossFit vs. Running .009
Is sustainably produced	10.667	.031	CrossFit vs. Running .020
Performance			
Is high in protein	73.671	< .001	CrossFit vs. Other < .001 CrossFit vs. Running < .001 CrossFit vs. Climbing < .001 CrossFit vs. Gym training < .001
Fuels my body for training	54.201	< .001	CrossFit vs. Other < .001 CrossFit vs. Running < .001 CrossFit vs. Climbing < .001
Makes me feel energetic for training/competition	34.309	< .001	CrossFit vs. Gym training .007 CrossFit vs. Other < .001 CrossFit vs. Running < .001 CrossFit vs. Climbing < .001
Helps my body with recovery	44.848	< .001	CrossFit vs. Other < .001 CrossFit vs. Running < .001 CrossFit vs. Climbing < .001
Helps me control my weight	24.388	< .001	CrossFit vs. Climbing < .001
Is similar to what other people in my sport eat	16.085	.003	CrossFit vs. Running .027 CrossFit vs. Climbing .002
Health			
Keeps me healthy	13.442	.009	CrossFit vs. Climbing .008
* For every item showing significant overall-difference in the Kruskal-Wallis test, Dunn-Bonferroni post-hoc analysis was performed. Degrees of freedom: 4.			

Choices of Protein sources

The most frequent protein sources that were consumed on a daily basis were grains (34.6%) and dairy products (32.2%). Grains had the highest median of 5–6 times per week, dairy products and nuts/seeds were following with the median of 3–4 times per week. The frequency of consumption of meat was overall relatively low. Of the total sample 31.9% never consumed red meat while 30% never consumed poultry. The highest frequency for fish and seafood was less than once a week with 39%. A less common use of protein sources in form of powder, supplements and bars in comparison to the other sources is demonstrated in Fig. 4 (c).

In the next step, the frequencies of the total sample ($N = 367$), people who ranked the importance of sustainability items high ($n = 114$) and people who ranked the importance of performance items high ($n = 119$) were compared. Poultry ($\chi^2 = 24.057$, $p < 0.001$) was more often consumed in the group who ranked performance as an important influence factor of their food choices than in people who ranked sustainability as important. Some plant-based protein sources were consumed very frequently. Especially grains were consumed the most on a daily basis, followed by nuts and seeds (17%). Least often consumed was tofu.

Overall, consumption of protein supplements was low compared to the other protein sources, with a median less than once a week. The most frequent used source of protein supplements were protein bars, the highest in the performance group. The largest difference between the performance and sustainability group was in the consumption of whey protein powder ($\chi^2 = 29.153$, $p < 0.001$). While 74.6% of the sustainability group never used whey powder, only 39.5% never used it in the performance group. Almost 17% of the performance group consumed whey protein powder daily. In the Appendix the frequencies of the consumption of different protein sources can be found (Appendix, Figure A.1–3).

In terms of different preferences in protein sources among different types of sports, some distinctions were observed in all three main protein groups, animal-based, plant-based sources and protein supplements. A total of 37% of people active in Climbing never consumed poultry compared to 21% of people active in CrossFit. The overall consumption of poultry and especially eggs were more frequent in people active in CrossFit in comparison to the other types of sport. Over 22% of the CrossFit-group consumed eggs daily. The daily consumption of dairy products was in all groups the highest source of animal-based protein. Figure 4 (a) gives an overview of the consumption of all animal-based protein sources. Significance levels can be found in Table 4.

The differences in plant-based protein sources were small between sport groups. Grains and nuts/seeds were consumed very frequently with the highest percentage of daily consumption. Figure 4 (b) presents all the frequencies of plant-based protein sources in between sport groups.

Even though protein supplements were the least frequent consumed protein sources, there were some group specific variations identified. Figure 4 (c) depicts those group specific differences. Protein bars were the most frequent used supplement overall. The consumption of protein bars was the highest within

the group of CrossFit. The largest group differences were identified in whey protein powder. Over 70% of all people active in CrossFit consumed whey protein powder at any frequency, almost 24% daily, whereas in all other sport groups at least 66% never consumed whey protein powder at all.

Regarding the differences in choice of protein sources among active in different sports, the Kruskal-Wallis test also showed the most significant differences in CrossFit in relation to the other sports. The protein sources that showed a high relationship were eggs, whey protein powder, protein bars and other protein supplements each with an asymptotic significance level of $< .001$. Every protein source is shown in more detail in Table 4.

Table 4
Comparison of main sports and frequency of consumed Protein sources.

Protein sources	Kruskal-Wallis H	Asymp. Sig.	Post-hoc analysis* p-value ≤ 0.05
Animal-based protein			
Poultry	21.296	< .001	CrossFit vs. Running 0.33 CrossFit vs. Climbing < .001
Eggs	27.752	< .001	CrossFit vs. Gym training .044 CrossFit vs. Climbing < .001 CrossFit vs. Running < .001
Fish/seafood	14.671	.005	CrossFit vs. Climbing .004
Protein supplements			
Protein powder (whey)	94.024	< .001	CrossFit vs. Gym training < .001 CrossFit vs. Running < .001 CrossFit vs. Climbing < .001 CrossFit vs. other < .001
Protein bars	36.411	< .001	CrossFit vs. Climbing < .001 CrossFit vs. Gym training .002 CrossFit vs. Running < .001 CrossFit vs. other < .001
Other protein supplements	28.630	< .001	CrossFit vs. Gym training .006 CrossFit vs. Climbing < .001 CrossFit vs. other .005 CrossFit vs. Running .001
*For every item showing significant overall difference in the Kruskal-Wallis test, Dunn-Bonferroni post-hoc analysis was performed. Degrees of freedom: 6.			

Concerning the level of physical activity, there were some significant differences in the frequency of consuming specific protein sources as well. The participants with higher physical activity levels consumed eggs ($p < .001$), whey protein powder ($p < .001$), protein bars ($p < .001$) and other protein supplements ($p = .012$) more frequently than the participants with lower physical activity levels (0–3 hours per week). The persons with the highest physical activity levels were active in CrossFit (26% 6–7

hours per week, 32% > 7 hours per week) and Climbing (15% 5–7 hours per week, 28.5% > 7 hours per week. The test findings are summarized in the Appendix (Table A.1).

Additionally, the influences of food choices regarding performance ($p < .001$), protein content ($p < .001$) and the similarity to what other people in the same sport are eating ($p = .013$) showed a statistically significant difference at $p < 0.05$ between the groups with lower and higher physical activity levels. There were no significant differences regarding the importance of sustainability in samples with different physical activity levels. These findings are summarized in the Appendix (Table A.2).

The sport group of Running ranked the items related to sustainability higher in importance (Fig. 2), and 74% of all Runners were living in Germany. Nevertheless, the overall distribution of all five sustainability items were nearly the same in both countries. Of the German sample 30.5% and 31.7% of the Swedish sample ranked all sustainability items as moderately or very important (Appendix, Table A.3).

4. Discussion

This study shows that sustainability was ranked in average moderately important in the overall sample, while taste and healthy food were ranked the most important influence factors on food choices. Participants active in CrossFit or with higher physical activity level ranked performance related items the most important influence on their food choices. On the other hand, importance of sustainability related items was ranked the highest among participants active in Running.

In a previous study, sustainability was ranked less important while our participants ranked it moderately important (13). Therefore, it is important to note that participants active in Running, and followed by Climbing, ranked items in the current study related to sustainability most important. Running and Climbing are both outdoor sports, which raises the question if there is some connection between environmental awareness and outdoor sports. There is a range of studies that examined the effects of outdoor activities and teachings on environmental awareness (14,15), but less attention is addressed to associations between outdoor sports and attitudes towards nature and environment (16). Beery demonstrated 2013 that “friluftsliv” (outdoor life), defined as nature-based outdoor recreation, was positively related to environmental connectedness (14). In an exploratory study of extreme outdoor sport athletes from MacIntyre et al. from 2019, the connection with nature and influence on pro-environmental behaviour was examined. The authors concluded that engaging with nature can have an impact in individuals’ environmental concern (17). One important underlying motive for being physically active in nature is the opportunity to experience nature (18). This connectedness to nature can effectively contribute to environmental management goals (19). Being so close to nature brings people also closer to experience the consequences of climate change. Cunningham et al. explored that physically active people experience the consequences of climate change and therefore believe that climate change personally affects them (16). However, these findings did not include any pro-environmental behaviour related to nutrition or food choices.

Taste and health

As mentioned above, the items of taste and health were the most important underlying motives on food choices in the current study. This confirms the same findings of other studies identifying health and sensory appeal of the food, including taste, as one of the most important influencing factors when it comes to food choices (13,20–22). As health aspects of physical activity can be one underlying motivation for participation in sports (7), the choice of health promoting food can be another supportive factor for achieving a healthier lifestyle. A healthy diet is also an important aspect in athletes. Especially important is consuming food that helps preventing reduction of immune function following intensive training (6). These aspects could influence the importance of health in food choices.

Differences between sports

Another research question of this study was, if influences on food choices and consumed protein sources differed between sports. Focusing on the influences on food choices, participants with higher physical activity levels and active in CrossFit ranked performance related items as important. Performance related items were that the food consumed *“is high in protein”, “fuels the body for training”, “makes me feel energetic for training”* and *“helps my body with recovery”*. To the knowledge of the authors, no former studies have focused on food choices specifically in high- intensity strength training like CrossFit. Two studies identified influences on food choices in college football players (10) and hockey players (8). The most important influences on food choices were performance, health and taste, which is consistent with our findings. Performance and health were interrelated themes in both studies with football- and hockey players, the participants described that without healthy, nutritious food, their performance in their sport would be negatively affected (8,10). In concordance, participants active in CrossFit in our study, ranked performance and health related items very important. In the group of football-players, the primary goal was consuming high-protein foods (10), in the hockey group, foods that help them having high energy levels and explosiveness in the training (8). Further, respondents active in CrossFit in the current study likewise ranked high-protein foods and food that helps them to feel energetic in training very important. In addition, Birkenhead and Slater described performance expectations as most important determinant on the food choices of athletes, but emphasizes the influence of the competitive level, phase of season and type of sport people are active in (7). The findings of Birkenhead and Slater are in line with our results, as differences in physical activity levels and different types of sports showed distinctions in motives for food choices.

Regarding proteins, grains were the most frequent consumed protein source in the total sample of this study. Grains are one major source of dietary protein intake globally and wheat represents the biggest group of plant-based protein source in the Western diet, most commonly in the form of bread (23,24). The most frequent used animal-based protein sources in all different sports in this study were dairy products. At least 20% of participants active in each sport group consumed dairy products daily. These findings are in line with Gillen et al., who identified bread as the most frequent consumed plant-based protein source and dairy products as second largest animal-based protein sources in a sample of athletes (25). Dairy proteins in general are a high-quality dietary protein source due to their high content of leucine (5). This characteristic could be a contributing factor explaining the frequent consumption of dairy products. The

Swedish Food Agency (Livsmedelsverket) as well as the German Nutrition Society (Deutsche Gesellschaft für Ernährung) recommend consuming dairy products daily (26,27). The amount of dairy products consumed daily (e.g., in millilitre or gram) of the participants in this study is not clear. Therefore, it is not comprehensible, if it is a higher amount than recommended in the national and international guidelines.

Even though overall meat consumption was less frequent, participants active in CrossFit and having higher physical activity levels consumed poultry and eggs significantly more frequently compared to other sports and lower physical activity levels. Literature describes both protein sources as eligible for physically active individuals (6). There are some former findings that confirm poultry being a frequently used protein source in athletes (10,25).

Regarding protein supplementation, participants with higher physical activity levels and active in CrossFit used protein supplements most frequent. These results are consistent with the findings of Gillen et al. who explored protein supplementation in different kind of sports. They came to the conclusion that the prevalence of protein supplementation was the highest in people active in strength training compared to team-sport and endurance-sport (25). In our findings, whey protein powder was used in 70% of all respondents active in CrossFit when all frequencies were included. Whey proteins are the most extensively researched for pre/post resistance exercise supplementation (6) and is a common choice among physically active individuals. Reasons for that could be the high leucine content, rapid digestibility, and ability to maximally stimulate muscle protein synthesis (28). The consumption of plant-based protein powder was less frequent than whey protein powder. Plant-based protein supplements however could be an important source for a shift to a more sustainable diet in physically active individuals.

Soy is the most researched plant-based source of protein (6). In a meta-analysis from 2018, Messina et al. compared the results of nine studies addressing the effect of soy protein on strength and lean body mass in comparison to animal-based proteins. The authors came to the conclusion that supplementation with soy has similar effects on gaining strength and lean body mass as whey protein with no significant difference between both groups (29). There are other plant-based protein sources besides soy, e.g., pea, rice and hemp. Research that examines the ability of those sources to modulate exercise performance and training adaptations is limited at this time (6). Rice protein promoted in some studies resistance training adaptations (30,31), which were similar to whey protein. Babault et al., 2015 examined the outcome of oral pea protein supplementation on biceps brachii muscle thickness and strength in comparison to whey protein and a placebo-control group. Their findings suggest that pea protein supplementation showed a significantly greater effect on muscle thickness than the placebo and similar to whey protein (32). Banaszek et al. conducted a pilot study about the effects of pea protein powder in people active in high-intensity functional training. Their findings suggested that whey and pea protein powder promote similar strength, performance, body composition, and muscular adaptations following eight weeks of training (28). Scientific data about the influence of a plant-based diet on physical performance is limited. This is a growing area of research interest and important for a more sustainable intake among athletes.

An important strength of this study is that it combines a diverse sample of physically active people. Different physical activity levels and types of sports, including indoor and outdoor sports as well as endurance and strength sport, make it possible to compare motives and actions concerning food choices among those groups. This can give some impact for further studies examining specific groups more detailed. The fact that one of the authors personally supervised the participants while conducting made it possible giving answers and help if there were any raising questions or difficulties with understanding the survey. By inspecting underlying food choice motives and additionally consumed protein sources, a comparison between inner attitudes and actual behaviours and actions of the participants can be made. Therefore, either a discrepancy or an accordance between the underlying motives of food choices and the actual consumed protein sources could be an area of interest in additional research.

The original four-point Likert scale of the *Food Choice Questionnaire* (11) was used (dimensions of *not important*, *a little important*, *moderately important* and *very important*). This can be considered to more or less to force the participants to be more radical in their choice, but the choice of removing the neutral option is intentional as this often becomes the easier answer. In a larger sample, a nine-point scale as suggested as by Cunha et al. in their systematic review from 2018 could be advantageous. Nine dimensions in the FCQ could provide a finer discrimination and therefore avoid extreme responses and reduce response bias (33). The choice of the four-point Likert scale was made after searching the literature in our field and to be able to make our study comparable with other studies on food choices.

Since only some items from the FCQ and AFCQ were adopted, it would be important to carry out an exploratory factor analysis in order to identify potential new underlying factors. Cunha et al. state in their systematic review, that it would be important for future research to use one version of the FCQ that can be applied in several studies (33). Otherwise, a comparison of results is challenging.

The assessment of the physical activity level was very difficult for some subjects of the sample. Depending on the level of fitness, interpretation of when a vigorous physical activity begins differed. The classification of the physical activity level was roughly based on the International Physical Activity Questionnaire (9). Even though the IPAQ is the most widely used physical activity questionnaire (34), it has its limitations. The short version (IPAQ-SF) can overestimate physical activity in a high average. Correlations between the score of the IPAQ-SF and objective measures of activity was in the most studies lower than the acceptable standard (35).

The hours of physical activity are also dependent on the type of sport. Although climbing usually takes more hours per training session than a CrossFit session, this does not mean that the level of training intensity can be measured and compared with each other. For further research, it may be more helpful to ask about the number of training sessions within a sports group.

Another aspect that shows some limitations is the frequencies of protein sources being asked in the questionnaire. There were possibilities that the answer could be interpreted as “times per week” or as “portions per week” which could mean different results. But as this study does not focus on absolute intake, the accuracy is regarded to be sufficient.

A future shift to more sustainable diets and reduced carbon footprint from foods in all groups in the society, also physically active individuals, is required. Large groups with high physical activity and athletes will only comply if this can be achieved without negative impact on performance and health. Therefore, future studies addressing underlying motives for food choices and effect of plant-based protein sources on physical performance would be helpful.

Besides studies investigating the effects of plant-based protein on physical performance, qualitative approaches would be beneficial to gain insights of the willingness and motivation of athletes consuming plant-based protein sources.

5. Conclusions

The data of this study indicates that there are distinctions between different types of sports as well as physical activity levels related to food choices and frequency of consumed protein sources. Getting more insights about underlying motives, especially the attitude towards sustainability of food choices in athletes, is important. The broad findings of this study show that the participants' influences on food choices and actual consumption of protein sources differ between different types of sport and physical activity levels. In order to reach the goal to decrease the food consumptions' climate impact overall it is important to include groups with high physical activity since they generally have higher energy expenditure. That together with high protein consumption thereby contribute to a higher carbon footprint than the general population. Thus, changes in this group could have a major impact on sustainability aspects.

Declarations

Ethics approval and consent to participate

The study followed ethical rules and when invited, the participants were informed about the purpose of the study, that participation was optional and that the collected data was anonymous.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no conflict of interest.

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Authors' contributions

Cosima Nuszbaum: Conceptualization, Formal analysis, Writing -original draft, Visualization, Writing - review & editing. **Mari Wollmar:** Conceptualization, Writing - review & editing. **Agneta Sjöberg:** Conceptualization, Writing - review & editing.

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Figures

Figure 1

Figure 2

Ranking of importance of Food Choice Questionnaire-items relating to Sustainability between different types of sports. Group frequencies were scaled to 100%. Different sample sizes of each group were: CrossFit: n= 84, Climbing: n= 137, Gym training: n= 62, Running: n= 46, Other type of sport: n= 38.

Figure 3

Ranking of importance of Food Choice Questionnaire-items related to Performance between different types of sports. Group frequencies were scaled to 100%. Different sample sizes of each group were: CrossFit: n= 84, Climbing: n= 137, Gym training: n= 62, Running: n= 46, Other type of sport: n= 38.

Figure 4

(a) shows the Frequencies of consumption of animal-based protein sources divided into types of sports, Figure 4 (b) the Frequencies of consumption of plant-based protein sources and Figure 4 (c) the

Frequencies of consumption of protein supplements among different types of sport. Group frequencies were scaled to 100%. Different sample sizes were: CrossFit: n= 84, Climbing: n= 137, Gym training: n= 62, Running: n= 46, Other type of sport: n= 38. The colour of frequencies can be found in the legend in Figure 4 (c).

Supplementary Files

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