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Musculoskeletal health in esport: a cross-sectional comparison of musculoskeletal pain among young Danish esports players and handball players

Supplementary Information

The online version of this article (https://doi.org/10.1007/s12662-024-00948-4) contains supplementary material, which is available to authorized users.

Introduction

Competitive gaming (esports) has gained increasing popularity among adolescents and young adults (Lindberg et al., 2020; Nagorsky & Wiemeyer, 2020). Esports players compete in various digital games through a computer, console, or smartphone, both online and at large events with thousands of spectators and millions of dollars in prize money (Lam et al., 2022; McGee, Hwu, Nicholson, & Ho, 2021; Pereira, Brito, Figueiredo, & Verhagen, 2019). With the increased recognition and commercial interest in esports, more awareness has been directed toward esports players' mental and physical health. As such, larger esports organizations have employed performance teams consisting of health professionals such as mental coaches, physiotherapists, and medical doctors to help the players stay in good health and ready for competition. Musculoskeletal (MSK) pain, especially related to the back and wrist, was found to be highly prevalent among professional esports players (DiFrancisco-Donoghue, Balentine, Schmidt, & Zwibel, 2019; Lam et al., 2022). Moreover, one study found that 42% of young amateur esport players experienced (MSK) pain (Lindberg et al., 2020). This is important as amateur players may not have the same access to healthcare as professional players do. Although continuously debated, one of the underlying mechanisms for MSK pain in esports is thought to be the high training volume to which many esports players are exposed (DiFrancisco-Donoghue et al., 2019; Lindberg et al., 2020).

The average training volume among amateur esports players was found to be more than 24 h/week (Lindberg et al., 2020). One study showed that esports players with MSK pain during the previous week had a significantly lower training volume than those without MSK pain (Lindberg et al., 2020). As such, MSK pain may limit participation among amateur esports players. Notably, the weekly training volume among professional esports players could be three times higher than amateur players (DiFrancisco-Donoghue et al., 2019). This is important, as an emerging concern in esports is related to mental health issues and activity-limiting burnout, which may be associated with the high training volume (Hong, Wilkinson, & Rocha, 2022). As such, health professionals have raised several concerns about esports and have called for additional research on health in esports (McGee et al., 2021). As esports appeal to the younger population, additional knowledge on health and risk factors is warranted to support the young players.

Although the prevalence of MSK pain is high within esports, no previous study has made a direct comparison of MSK pain prevalence between esports players and non-esports players who participate in other recreational activities. In addition, it remains to be investigated whether MSK pain decreases training volume across different populations of amateur esports players, thus replicating the results reported by Lindberg et al. (Lindberg et al., 2020).

Therefore, the aims of this study were (1) to compare MSK pain prevalence among amateur esports players and another group of sports-active amateur players and (2) to investigate whether training volume among esports and handball players with MSK pain was different from esports and handball players without MSK pain. We hypothesized that MSK pain prevalence would be higher among handball players and that training volume would be decreased in both esports and handball players with MSK pain compared to players without MSK pain.

Preprint
For transparency and accessibility, we disclose that a copy of the manuscript has been made available on a pre-print server prior to submission: https://www.medrxiv.org/content/10.1101/2022.09.19.22279922v1

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Methods

Development and ethical considerations

This questionnaire-based cross-sectional study was conducted at the Department of Physiotherapy at University College of Northern Denmark, Aalborg, Denmark. The study protocol was developed from the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (von Elm et al., 2008).

The participants received written study information before providing written informed consent to participate. Approval to conduct the study was sought from the Ethics Committee of Northern Denmark. The committee replied that no approval was necessary for the current study (journal number: 2022-000764).

Choice of comparator

In Denmark, handball is the second most popular sport among adolescents and young adults, surpassed only by football (Danish Gymnastics and Sports Association, 2022). As both handball and esports appeal to the same age group, involve upper body segments and muscle groups, and are characterized by a high level of training volume, it is worth investigating whether MSK pain prevalence is higher in esports compared to handball. Furthermore, both esports and handball are popular activities among adolescents and young adults in many European countries such as Sweden and Germany.

Eligibility criteria

In the current study, we aimed to include 150 esports players and handball players within the available time frame of the study. The sample size was further based on previous experiences with recruiting adolescent esports players for similar research projects (Lindberg et al., 2020). In a previous study, we reached a sample 188 esports players. At the time of undertaking the current study, more than 104,000 adolescents between 13 and 25 years of age were registered as actively participating in handball in Denmark (The National Olympic Committee and Sports Confederation of Denmark, n.d.). For esports, the number of registered participants were 6000 at the time (The National Olympic Committee and Sports Confederation of Denmark, n.d.). Taking these numbers into account, we found it to be realistic to include 150 adolescents from each activity prior to undertaking the study. Eligible players had to be between 15 and 25 years of age and participate in structured esports or handball (defined as training with a coach present). This approach was used in a previous study to recruit esports players for a similar research project (Lindberg et al., 2020). By only including players who participate in structured esports and handball with a coach present, we aimed to exclude causal esports and handball players from participating in the study as they may differ from competitive esports and handball players. Esports players were required to primarily participate in esports through a computer-based game. Eligible esports players and handball players were sought out at community-based teams, professional organizations, and educational institutions via emails, phone calls, and through the authors' network in esports and handball. Players were, in addition, recruited from competitive tournaments and through social media.

Distribution of questionnaire

The questionnaire was developed and distributed through SurveyXact (Rambøll Management Consulting, Århus H, Denmark). The questionnaire was pilot tested among both esports players and handball players to evaluate the completion time and relevance. The length of the questionnaire was deemed appropriate, and the questions were found easy to understand. No major changes to the questionnaire were made based on the pilot test.

Player characteristics

All players were asked to provide name, email, phone number, age, sex, height, weight, level of play (amateur, semi-professional, or professional) and to state in which context they participated in their activity (e.g., professional team or educational institution). Esports players were required to state the title of their primary competitive game.

Outcome and additional assessments

Primary outcome

The primary outcome was "Have you experienced pain in your body during the previous week?" This question was answered with "yes" or "no." This method was used as the primary outcome in a previous study investigating MSK pain prevalence in amateur esport players (Lindberg et al., 2020).

Pain measures

Participants who answered "yes" to the initial question about MSK pain were subsequently asked to state their primary pain site. Pain intensity was assessed as the worst pain during the previous week at the primary pain site with an 11-point Numeric Pain Rating Scale (0 = *no pain*, 10 = *worst possible pain*). Pain frequency was investigated with a 5-point rank scale ranging from *daily* to *seldom*. The prevalence of activity-limiting pain was assessed with a single question: "Have you had difficulties participating in your sports due to your pain?"—which could be answered with "yes" or "no." These pain measures were used in previous research to assess activity-limiting pain among adolescents with MSK pain who participated in sports and esports (Lindberg et al., 2020; Rathleff et al., 2019).

Activity-limiting burnout

Activity-limiting burnout among esports players and handball players was investigated with a single question, "Have you within the previous 3 months experienced the feeling of burnout to such an extent that you could not participate in your sports?" This question was answered with "yes" or "no."

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Musculoskeletal health in esport: a cross-sectional comparison of musculoskeletal pain among young Danish esports players and handball players

Abstract

Purpose. There is a continuous debate regarding musculoskeletal (MSK) pain prevalence and training volume among amateur esports players. Previous findings suggest that MSK pain may limit esports participation in this group; however, these results have yet to be replicated in a similar population. It also remains to be investigated whether MSK pain is more prevalent in esports compared to other activities, such as handball. The objectives were (1) to compare MSK pain prevalence among amateur esports players and another group of sports-active amateur players and (2) to investigate whether MSK pain would impact training volume in the two groups.

Methods. Eligible players for this cross-sectional study had to engage in either structured esports or handball and be 15–25 years of age to participate. Demographic data, self-reported MSK pain prevalence, training volume, sleep patterns, physical activity level, and activity-limiting pain and burnout were obtained through online questionnaires.

Results. In total, 76 esports players and 175 handball players were included. Overall, 48% of esports players and 80% of handball players experienced MSK pain. The odds of experiencing MSK pain were significantly lower in esports compared to handball (OR: 0.24, 95% CI 0.13–0.43, chi-square $p < 0.001$). There was no significant difference in training volume between players with or without MSK pain in either group. Esports players had significantly higher training volume (additional 13 h/week, $p < 0.001$) compared to handball players.

Conclusion. These findings indicate that esports players are not at increased odds of experiencing MSK pain compared to handball players despite significant differences in training volume.

Keywords

Esport · Handball · Musculoskeletal pain · Training volume · Burnout

Muskuloskeletale Gesundheit im E-Sport: ein Querschnittvergleich muskuloskeletaler Schmerzen bei jungen dänischen E-Sportlern und Handballspielern

Zusammenfassung

Ziel. Es gibt eine ständige Diskussion in Bezug auf die Prävalenz muskuloskeletaler Schmerzen (MSK) und den Trainingsumfang bei E-Sport-Amateuren. Früheren Ergebnissen zufolge können MSK-Schmerzen die Teilnahme am E-Sport in dieser Gruppe begrenzen, jedoch müssen diese Ergebnisse noch in einer ähnlichen Population wiederholt werden. Ebenso bleibt zu untersuchen, ob die Prävalenz von MSK-Schmerzen im E-Sport höher ist als bei anderen Aktivitäten wie z. B. Handball. Ziele waren 1) der Vergleich der MSK-Schmerz-Prävalenz bei E-Sport-Amateuren und einer anderen Gruppe aktiver Amateursportler sowie 2) die Untersuchung, ob MSK-Schmerzen Einfluss auf den Trainingsumfang innerhalb der beiden Gruppen haben.

Methoden. Für diese Querschnittstudie geeignete Spieler mussten entweder strukturierten E-Sport oder Handball betreiben sowie im Alter von 15–25 Jahren sein, um teilzunehmen. Demografische Daten, eigene Angaben zur Prävalenz von MSK-Schmerzen, Trainingsumfang, Schlafmuster, körperliches Aktivitätsniveau und aktivitätsbegrenzende Schmerzen sowie Burn-out wurden anhand von Online-Fragebögen erfasst.

Ergebnisse. In die Studie wurden 76 E-Sportler und 175 Handballspieler eingeschlossen. Über MSK-Schmerzen berichteten 48% der E-Sportler und 80% der Handballspieler. Die Wahrscheinlichkeit, unter MSK-Schmerzen zu leiden, war beim E-Sport signifikant geringer als beim Handball (Odds Ratio, OR: 0,24; 95%-Konfidenzintervall, 95%-KI: 0,13–0,43; Chi^2-p-Wert < 0,001). Es bestand kein signifikanter Unterschied beim Trainingsumfang zwischen den Spielern mit und denen ohne MSK-Schmerzen in beiden Gruppen. E-Sportler hatten einen deutlich höheren Trainingsumfang (zusätzlich 13 h/Woche, $p < 0,001$) als Handballspieler.

Schlussfolgerung. Diese Ergebnisse zeigen, dass E-Sportler kein erhöhtes Risiko für MSK-Schmerzen im Vergleich zu Handballspielern haben – trotz signifikanter Unterschiede beim Trainingsumfang.

Schlüsselwörter

E-Sport · Handball · Muskuloskeletaler Schmerz · Trainingsumfang · Burn-out

Training volume

Training volume was assessed with three individual questions. Firstly, structured training volume was defined as the number of hours per week each player practiced esports or handball with a coach present. Secondly, the number of hours per week each player practiced esports or handball without a coach present was defined as unstructured training volume. Lastly, the number of hours per week each player was engaged in competition or tournament activities was assessed. In the current study, the total weekly training volume was defined as the sum of weekly structured and unstructured hours of training in esports and handball. This strategy was used in a previous study to investigate training volume in esports (Lindberg et al., 2020). Using this approach, it was possible to compare the findings from the current study with previous findings.

Physical activity levels

Physical activity levels were assessed with two separate questions. The first question assessed the number of days per week each player was physically active at moderate intensity. The second question investigated the number of days per

week each player was physically active at high intensity. Each question could be answered on an 8-point rank scale ranging from 0 to 7. These two questions were supplemented with the following text: "Moderate intensity is physical activity where you feel shortness of breath, but you can keep a conversation going. High intensity is physical activity where you feel shortness of breath and you experience difficulties keeping a conversation going." These questions were framed based on the Danish national recommendations for physical activity among children, adolescents, and young adults (Danish Health Authority, 2022).

Use of analgesics

The frequency of analgesic use due to pain in the previous 3 months was assessed among players who had indicated analgesic use with a 5-point rank scale ranging from *daily use* to *seldom use*.

Sleep patterns

Sleep patterns were assessed as the quantity of sleep and sleep quality. Sleep quantity was investigated as the average hours of sleep each player would get during the night. Sleep quality was assessed with four separate questions which enquired about: (1) trouble falling asleep in the evening; (2) waking up several times during the night; (3) trouble sleeping through the night; and (4) feeling tired in the morning when waking up. Each of these four questions was answered on a 4-point rank scale: (1 = *No, not at all*; 2 = *Yes, some nights/mornings*; 3 = *Yes, most nights/mornings*; 4 = *Don't know*). Similar questions were used in previous studies to assess sleep patterns in adolescents and young adults (Lindberg et al., 2020; Rathleff et al., 2019).

Data analysis

All statistical analyses were undertaken with IBM SPSS version 28 (New York, United States). The Pearson's chi-square test was used to compare MSK pain prevalence between the two activities, and the odds ratio was used to express the association between type of activity and MSK pain. To investigate whether the training volume differed between players with and without MSK pain among players within the two groups, we used the independent sample *t* test to compare total weekly training volume (total hours of structured and unstructured training per week). A value of $p < 0.05$ was considered statistically significant. Data from two handball players were missing for measures related to analgesic use, pain frequency, pain location, pain intensity, and activity-limiting pain. Further, data from four handball players were missing for measures related to physical activity levels, activity-limiting burnout, and sleep patterns.

Results

From 20 April 2022 to 6 July 2022, 279 players responded to the questionnaire. Of these, 19 did not respond to the primary outcome, and nine did not meet the eligibility criteria. We included 76 esports players and 175 handball players (251 in total) from Denmark. See **Table 1** for additional data regarding player characteristics and Online Resource 1 for findings on the use of analgesics, physical activity level, and sleep patterns.

MSK pain prevalence, location, and association with the type of activity

The primary analysis showed that esports players had significantly lower odds of experiencing MSK pain during the previous week compared to handball players (OR: 0.24, 95% CI 0.13–0.43, χ^2 $p > 0.001$). Overall, 37 (48.7%) esports players and 140 (80%) handball players experienced MSK pain during the previous week. Of these, the most common pain sites were the back (32%) and the hand/fingers/wrist (24%) among esports players and the knees (26%) and shoulders (13%) among handball players. Of those reporting pain, 54% of the esports players and 52% of the handball players experienced pain daily or several times per week. Among those reporting pain, 16% of the esports players and 30% of the handball experienced activity-limiting pain. On average, esports players and handball players reported worst pain intensities during the previous week of 4.4 (95% CI 3.6–5.1) and 4.9 (95% CI 4.7–5.3), respectively.

Training volume in players with and without MSK pain

We found no significant difference in total weekly training volume among esports players with MSK pain (22.3 h/week, 95% CI 17.1–27.45) and without MSK pain (23.6 h/week, 95% CI 17.8–29.4) during the previous week ($p = 0.727$). Further, we found no significant difference in total weekly training volume among handball plays with MSK pain (9.2 h/week, 95% CI 8.5–9.9) and without MSK pain (8.1 h/week, 95% CI 6.8–9.3) during the previous week ($p = 0.128$).

Explorative analysis

Due to a substantial difference in weekly training volume between the two groups, we conducted an explorative test for comparison. From the analysis we found that the difference was statistically significant ($p < 0.001$) with the esports players having 13.9 h (95% CI 10.1–17.8) of additional training volume per week compared to the handball players. The difference remained statistically significant when hours of weekly competition or tournament activities were included in the analysis (14.4 h/week, 95% CI 10.4–18.5, $p < 0.001$).

Discussion

Summary of findings

In this study, we found the prevalence of MSK pain during the previous week to be 48.7% and 80% within esports and handball, respectively. As hypothesized, we found that the prevalence of MSK pain during the previous week was higher among handball players than esports players and the odds of experiencing MSK pain were significantly lower among esports players. Although the prevalence of weekly MSK pain was

Table 1 Participant characteristics

Variables	All ($n = 251$)	Esports players ($n = 76$)	Handball players ($n = 175$)
Age (years)	17.8 (2.6)	19.1 (2.9)	17.2 (2.2)
Sex, *n* males (%)	163 (64.9)	66 (86.8)	97 (55.4)
Height (m)	1.80 (0.09)	1.82 (0.08)	1.79 (0.09)
Weight (kg)	76.3 (15.9)	79.2 (19.3)	74.9 (14.1)
Body mass index (weight/height^2)	23.3 (4.0)	23.7 (5.5)	23.1 (3.2)
Musculoskeletal pain during the previous week, *n* reporting yes (%)	177 (70.5)	37 (48.7)	140 (80)
Activity-limiting burnout during the previous 3 months, *n* reporting yes (%)[a]	89 (30)	26 (34)	63 (37)
The primary game, n (%)			
Counter Strike Global Offensive (CS:GO)	–	37 (48.7)	–
League of Legends (LOL)		24 (31.6)	
Other		15 (19.7)	
Setting for participation, n (%)			
Educational institution	105 (41.8)	59 (77.6)	46 (26.3)
Community-based team	85 (33.9)	5 (6.6)	80 (45.7)
Pro-team	49 (19.5)	2 (2.6)	47 (26.9)
Other	12 (4.8)	10 (13.2)	2 (1.1)
Level of play, n (%)			
Amateur	218 (86.9)	57 (75)	161 (92)
Semi-professional	29 (11.6)	17 (22.4)	12 (6.9)
Professional	4 (1.6)	2 (2.6)	2 (1.1)
Hours of structured training/week (95% CI)	6.1 (5.7–6.6)	6.6 (5.4–7.7)	5.9 (5.4–6.3)
Hours of unstructured training/week (95% CI)	7.1 (5.8–8.4)	16.3 (12.7–19.8)	3.1 (2.7–3.4)
Total hours of training/week (95% CI)	13.2 (11.8–14.7)	22.9 (19.2–26.8)	8.9 (8.3–9.6)
Hours of competition/week (95% CI)	2.3 (2.1–2.6)	2.6 (2.0–3.25)	2.2 (1.9–2.4)

Data are presented with mean and standard deviation unless otherwise specified
[a]Data are available for 76 esports players and 171 handball players (247 in total)

high, not all esports players nor handball players were limited during their activity due to pain. Furthermore, we found no significant difference in training volume among players with and without MSK pain neither in esports nor in handball. The prevalence of activity-limiting pain was lower among esports players compared to handball players. In both groups, more than one player in every three had experienced activity-limiting burnout during the previous 3 months.

Comparison with previous findings

To the best of our knowledge, this is the first study to directly compare MSK pain prevalence between esports and another type of activity appealing to individuals in the same age group. Previous studies on MSK pain and health in esports are limited by not including a control group of non-esports players for comparison (DiFrancisco-Donoghue et al., 2019; Lindberg et al., 2020). Therefore, it has not been possible to determine whether young esports players have greater odds of experiencing MSK pain compared with young individuals participating in other activities.

Findings on MSK pain prevalence, pain location, and cases of activity-limiting pain among esports players from the current study are similar to findings from previous studies among amateur and professional esports players competing in computer-based games (DiFrancisco-Donoghue et al., 2019; Lindberg et al., 2020). As such, there is consistent evidence to suggest that MSK pain is indeed prevalent in esports with more than four in every ten players reporting pain. In addition, more than 50% of the esports players and handball players affected by pain experienced pain daily or several times per week. This is especially interesting from an esports perspective as esports is characterized as a non-contact activity. These findings underline the need for more knowledge on the mechanisms and triggers for MSK pain in esports.

To the best of our knowledge, no previous study has aimed to investigate risk factors or specific mechanisms for MSK pain in esports players. However, it has been speculated that factors such as posture, training volume, or screen time (i.e., time spent sitting in front of the computer) may play a role in this regard (DiFrancisco-Donoghue et al., 2019; Lindberg et al., 2020). Findings from the current study and previous research demonstrate that MSK pain located at the back is prevalent in adolescent and young adult esports players (DiFrancisco-Donoghue et al., 2019; Lindberg et al., 2020). When compared to the prevalence of back pain among adolescents from the background population (Rathleff, Roos, Olesen, & Rasmussen, 2013), the proportion of

individuals with back pain was found to be higher in esports (Lindberg et al., 2020). Although these findings indicate an association between esports-related factors (e.g., posture, training volume, or screen-time) and back pain, one overview of systematic reviews found no clear evidence to support this association (Kamper, Yamato, & Williams, 2016). One important aspect to consider is that the reviews that were included in the overview, and which investigated these associations, were deemed of low quality and some were published before the year of 2000 (Kamper et al., 2016). These considerations warrant further high-quality investigations into the possible association between posture, training volume, or screen-time and back pain specifically within an esports population.

Contrary to previous findings (Lindberg et al., 2020), we found no difference in training volume among esports players with and without MSK pain in the current study. As such, we were unable to replicate the results from the study by Lindberg et al. (Lindberg et al., 2020). These inconsistent findings warrant further investigations regarding the possible impact of MSK pain on training volume among esports players. Interestingly, we found more than one in every three players from both esports and handball experienced activity-limiting burnout during the previous 3 months. These findings support prior speculation of activity-limiting burnout being prevalent in esport. However, our findings suggest that activity-limiting burnout is similarly prevalent in handball, despite the fact that esports players practiced their activity for significantly more hours per week compared to handball players. As such, this issue may be related to other factors than the type of activity and training volume. An association between training volume and activity-limiting burnout has been suggested previously (Hong et al., 2022); however, due to the small sample size and lack of a prior hypothesis, this relationship was not explored further in the current study.

Limitations

The study has some limitations. First, the number of esports players included was smaller than expected. From engaging with the esport community, this is most likely related to an intensified competition to engage Danish esports players in research projects. Second, due to the cross-sectional study design, it remains unknown whether the MSK pain was initiated via either esports or handball activities or not. As such, there is a need for prospective studies investigating the association between esports activity and MSK pain prevalence (Lindberg et al., 2020; McGee et al., 2021). Thirdly, physical activity levels were not assessed using a validated measure in the current study. In previous studies, we tried to assess physical activity levels with both the International Physical Activity Questionnaire short form and the Physical Activity Scale 2 with little success. From our experience, it seems these measures are inadequate to capture physical activity levels in populations of young esports players. The reason for this is unknown but may be related to the comprehensibility, length, and complexity of the measures. Nevertheless, an objective quantitative measure of physical activity (e.g., use of ActiGraphs or similar wearables) would have been preferred as self-reported measures of physical activity may be susceptible to bias (Dyrstad, Hansen, Holme, & Anderssen, 2014).

Lastly, the underlying mechanisms for MSK pain are likely to differ between esports and handball. As such, it may be assumed that the mechanism for MSK pain in esports might be more comparable to other non-contact activities such as chess or darts. However, individuals from Denmark engaged in these activities are considerably older compared to those engaged with esports (Danish Gymnastics and Sports Association, 2022; The Danish Chess Federation, 2022). A similar issue may arise when comparing MSK pain between young esports players and adult office workers. As such, the difference in age is likely to distort any comparison between esports and these activities as the prevalence of common MSK pain conditions such as low back pain increases with age (Hartvigsen et al., 2018). Therefore, comparing MSK pain prevalence between two activities that appeal to the same age group is likely to be a more appropriate comparison.

Outlook

It is widely acknowledged that participating in physical activities, such as handball, is positively associated with good physical health (Warburton & Bredin, 2017). However, like several other activities, handball is associated with health risks such as pain and injuries (Moller, Attermann, Myklebust, & Wedderkopp, 2012). Although the findings from the current study suggest the odds of MSK pain in esports are significantly lower when compared to handball, we also found an extensive training volume in esports. Compared to the training volume among handball players, the training volume of esports players is often associated with sedentary behavior. This is important as prolonged sedentary behavior is associated with chronic diseases such as cancer, diabetes, and cardiovascular conditions (Lee et al., 2012). As such, future research should investigate which type of physical activity appeals to esports players and develop methods to implement physical activity in esports.

Conclusion

These findings suggest that young amateur esports players do not have increased odds of experiencing musculoskeletal pain compared to young amateur handball players. This is despite esports players practicing their activity for an additional 1 h per week compared to handball players. More than one in every three players had experienced activity-limiting burnout in both esports and handball despite a significant difference in weekly training volume. This indicates that other factors besides type of activity and training volume may influence the occurrence of activity-limiting burnout.

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