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It's about timing: how density can benefit future research on the optimal dosage of acute physical exercise breaks in esports

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ABSTRACT
In recent years, organised and competitive video gaming, esports, has gained enormous popularity in many parts of the world, contributing to the growing professionalisation of this sports branch. To become or remain a professional esports player, individuals practice video gaming for several hours a day while remaining in a sitting posture which may not only lead to a decrease in training quality in the short term (eg, due to cognitive fatigue) but also put them at a higher risk for negative health events in the long-term (eg, overuse injuries). Thus, interrupting periods of prolonged video gaming in a sitting posture with acute physical exercise is strongly recommended for esports players even though the optimal dosage of acute physical exercise breaks remains unclear. To address this gap, we propose in this viewpoint that traditional concepts of exercise prescription and dosage determination using the variables frequency, intensity, time (also referred to as duration) and type of physical exercise (ie, abbreviated with the acronym FITT) should be complemented by the variable density which characterises the timing of consecutive bouts of acute physical exercise during an esports session.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Esports players spend several hours a day in a sitting posture which may decrease the training quality in the short term and increase the risk for negative health events in the long term.

⇒ To preserve and improve esports players' health, interrupting prolonged periods of sitting and video gaming with acute physical exercise breaks is recommended.

WHAT THIS STUDY ADDS

⇒ This viewpoint proposes that the variable density, which characterizes the timing of consecutive bouts of acute physical exercise breaks during an esports session, should be incorporated to complement traditional acute physical exercise prescription approaches.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE, OR POLICY

⇒ Considering density will allow for a more precise characterization and prescription of the dosage of acute physical exercise breaks, thus fostering a better understanding of the dose-response relationships.

BACKGROUND

Esports, defined as organised and competitive video/digital gaming,[1–3] has grown in popularity in recent years.[4] For example, more than 1.3 billion individuals regularly played video games worldwide in 2024.[4] Furthermore, there is evidence that the video game industry achieved revenue of US$1.2 billion in 2019[5] so it is not surprising that seeking a career as a professional esports player has become an attractive vocational opportunity among younger adults.[6 7]

Consequently, esports has garnered scientific attention which includes but is not limited to studies investigating the training routines of esports players[8–10] showing that esports training typically consists of practising video gaming for several hours a day (eg, up to 13 hours) while remaining in a sitting position.[2 8–10] Given that prolonged sitting in a relatively static posture during the esports training sessions can contribute to the numerous health issues reported by esports players (eg, musculoskeletal injuries and ocular problems),[10–15] it is recommended to integrate breaks with acute physical exercise defined as single bout(s) of planned and structured forms of physical activity[16 17] into esports training.[12 18]

Based on the evidence that (1) highly developed cognitive processes are a cornerstone for success in esports[19–22] and (2) extended periods of esports training can negatively influence the cognitive performance of esports players (ie, cause cognitive fatigue),[23]

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it seems reasonable to hypothesise that such esports training routines may lead to lower training quality in the short term and suboptimal esports performance development in the longer term. Thus, interrupting prolonged sitting during an esports session which often lasts several hours[2 8–10] with acute physical exercise, that typically lasts no longer than 35 min[24–26] and that can transiently improve cognitive performance[24–28] and esports performance,[29–31] may also be a crucial factor in ensuring high training quality, an important prerequisite for the optimal development of an athlete.[32]

However, neither the appropriate prescription nor the optimal dosage of acute physical exercise to interrupt periods of prolonged sitting during esports sessions is fully understood, necessitating future research.[2 28] We will use the term 'acute physical exercise breaks' to refer to bout(s) of acute physical exercise that breaks up prolonged periods of the same sedentary behaviour (eg, sitting and video gaming). Using cognitive performance as an example, we briefly discuss the current evidence on the influence and dosing of acute physical exercise breaks and highlight directions for future research.

THE INFLUENCE OF ACUTE PHYSICAL EXERCISE BREAKS AND GAMING PERFORMANCE OF ESPORTS PLAYERS

There is evidence that acute physical exercise can improve specific measures of cognitive performance (including gaming performance) in esports players.[28–31 33 34]

For example, in a within-subject cross-over study with post-test comparison, Las Heras and colleagues[29] observed in younger esports players a better gaming performance (ie, indicated by higher accuracy and capacity to eliminate targets in a League of Legends game) after 15 min of high-intensity exercise (ie, 5×1 min cycling at 80–85% peak power interspersed with 5×1 min light-intensity cycling at 40% peak power) compared with seated rest. In another between-subjects study with pretest–post-test comparison, Manci and colleagues[30] showed that an acute bout of sprint interval exercise (ie, 1×30 s sprint at all-out effort; preceded by a warm-up of 4 min at 50 watts) can improve the gaming performance of amateur esports players (ie, operationalised by the time to complete the Valorant game and assessed 30 min after exercise cessation). In addition, the randomised controlled trial of Rigthmire *et al*[31] provides evidence that college-aged esports players who conducted 18 min of high-intensity interval exercise (ie, 4×30 s sprints at maximal effort interspersed by 4 min active rest) immediately before an esports game have a significantly higher probability of winning the competition (ie, Super Smash Brothers Ultimate game) compared with controls who remained sedentary. It is important to mention that in this study the participants in both groups regularly engaged in esports tournaments and had a comparable esports skill level.[31]

Using a within-subject cross-over study design with pretest–post-test comparison, DiFrancisco-Donoghue and colleagues[34] observed that in highly competitive esports players interrupting a 2-hour esports session after 60 min with a 6-minute light-intensity walk (ie, an average score of 10.5 on the 6–20 rating of perceived exertion (RPE) scale) as compared with continuous play or rest in a supine position, improved planning performance (ie, operationalised by the Tower of London test) and self-perceived esports performance. However, the latter was not mirrored in objective measures (eg, percentages of games won).[34] Moreover, in another study using a comparable study design, DiFrancisco-Donoghue *et al*[35] noticed that a 6-minute light-intensity walking break (ie, an average score of 9.5 on the 6–20 RPE scale) mitigated the decline of peripheral blood flow (ie, measured at the popliteal artery) observed for continuous sitting even to a greater extent than wearing compression sleeves.[35] Based on the observation that in non-esports players (ie, healthy younger adults or desk workers), acute physical exercise breaks can counteract the negative effect of prolonged sitting on specific measures of cerebral blood flow,[36 37] it seems reasonable to assume that in esports players the positive effects of acute physical exercise breaks observed for measures of the peripheral blood flow may generalise to the cerebral blood flow. Addressing this gap in the literature is a promising area for future investigations given that acute exercise-induced change in cerebral blood flow is a putative candidate mechanism contributing to postexercise cognitive performance improvements.[24 38] However, further well-designed studies on esports players are required to test this assumption empirically.

While the above-presented evidence suggests that acute physical exercise can positively affect the gaming performance of esports players, the most effective dosage remains somewhat unclear.[28] To provide evidence-based recommendations for optimising esports training, we propose that future research is required to identify the optimal dosage of acute physical exercise to interrupt periods of prolonged sitting in esports training sessions.[28]

PRESCRIPTION AND OPERATIONALISATION OF THE DOSE OF ACUTE BOUTS OF PHYSICAL EXERCISE

Traditionally, frequency, intensity, time (also referred to as duration) and type of physical exercise (also referred to as the FITT principle; for definition see table 1) are used to characterise and prescribe the dosage of physical exercise.[16 39] Applying the FITT principle to investigate the dose-response relationship between acute bouts of physical exercise and cognitive performance (including gaming performance) has some merits. For example, there is evidence in the literature that the effects of acute exercise can be moderated by (1) exercise variables such as exercise intensity, exercise duration and type and mode of physical exercise, (2) individual characteristics such as age, fitness level or baseline level of cognitive performance and (3) other factors such as environmental conditions and type and time point of cognitive assessment,[24 27] although it is not well understood if these observations are readily generalisable to acute physical exercise breaks during periods of prolonged sitting[25 26] especially concerning the gaming performance of esports

Table 1 Definition of the terms included in the FITT principle[16 47 48]

Variable	Definition
Frequency	Refers to the number of physical exercise bouts in a specific time interval (eg, per day, week, month or year).
Intensity	Defines the level of exertion required by an individual to perform physical exercise.
Time	Refers to the time (duration) spent for a specific exercise or the entire exercise session.
Type	Characterises the type of physical exercise conducted in the exercise session (eg, endurance, resistance or coordinative exercise).

players because empirical research in this direction is scant.[28]

While the variables that form the FITT principle provide information on the number of acute physical exercise bouts per time interval (ie, frequency) or the characteristics of these acute physical exercise bouts (ie, intensity, time/duration and type of physical exercise), the FITT principle does not encompass all variables required to appropriately prescribe or determine the dosage of physical exercise.[16 17 39 40] For example, none of the variables forming the FITT principle provides information on the exact timing of consecutive bouts of acute physical exercise during a specific time interval (eg, minutes spent for esports practice between consecutive bouts of acute physical exercise breaks; see figure 1). In other words, from the perspective of the work-to-rest ratio, the FITT principle only specifies the 'work'. Still, it neglects the 'rest' because it does not provide information on the duration of the rest bout(s) between consecutive bouts of acute physical exercise during a specific time interval. Thus, to allow for a more precise determination and prescription of the dosage of acute physical exercise (eg, in esports training), we propose that the FITT principle should be complemented by a variable that characterises the timing of consecutive bouts of acute physical exercise during a specific time interval via specifying the duration of rest bout(s) between consecutive bouts of acute physical exercise (ie, the time spent for esports practice between physical exercise breaks). In the literature, such a variable has been termed density, in German known as 'Belastungsdichte' which is primarily defined as a physical training variable characterising the programming in a microcycle[39–41] (see figure 1).

Density is related to the work-to-rest ratio because a higher or lower density can be achieved by modifying the work-to-rest ratio via decreasing or increasing the time spent for rest (ie, time spent for esports practice or, in other words, the time interval between consecutive bouts of acute physical exercise breaks in an esports session; see figure 1) while keeping the characteristics of the work bouts constant (ie, type, intensity and duration of the acute physical exercise), respectively. Given that the work-to-rest ratio can be adjusted by changing both the duration of the work bouts (ie, duration of an acute physical exercise break) and/or the rest bout(s) (ie, time spent for esports practice), we use the term density, as done by others,[42 43] to specifically refer to changes in the duration of the rest bout(s) between consecutive work bouts.

Given that density can complement the FITT principle since it defines the time interval (eg, in minutes) after which periods of prolonged sitting (eg, esports practice) should be interrupted with acute physical exercise breaks (see figure 1), we propose that considering this variable is highly relevant not only for esports training but also for other activities involving periods of prolonged sitting (eg, office work).[39]

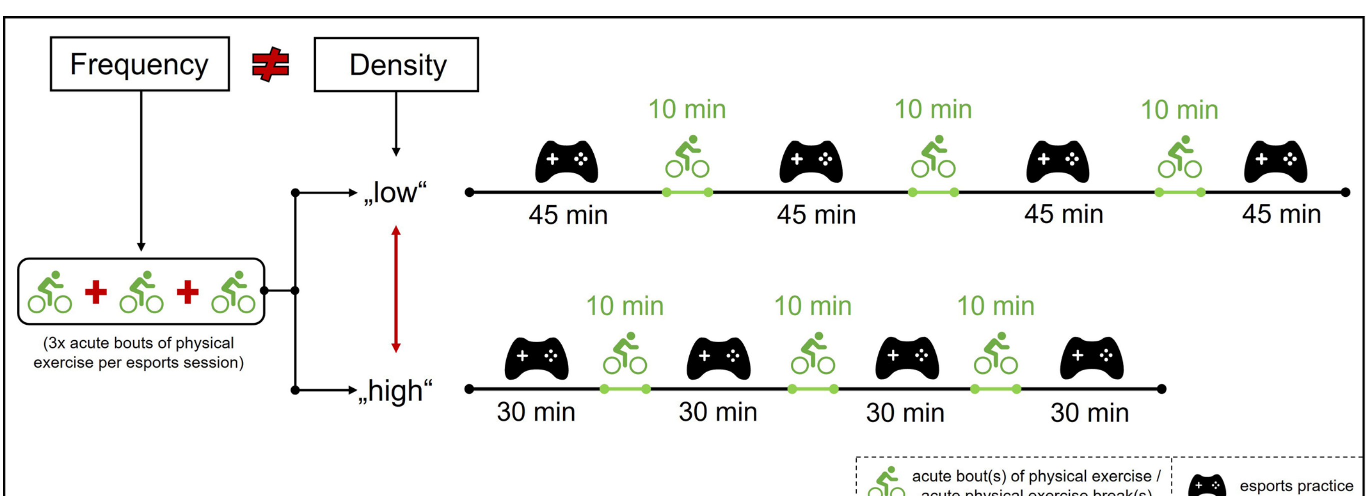

Figure 1 Schematic illustration of the variable density in the context of an esports session.

That density can play an important role in practical and research applications is supported by the findings of two systematic reviews investigating the effects of acute physical exercise breaks on cognitive performance during periods of prolonged sitting.[25 26] In both systematic reviews, it is speculated that during periods of prolonged sitting, the effects of acute physical exercise breaks on measures of cognitive performance depend on the frequency of such breaks.[25 26] However, the variable frequency does not provide information on the timing of acute physical exercise breaks within a session (ie, the exact time between consecutive bouts of acute physical exercise breaks; see figure 1) reinforcing the idea that considering density alongside other exercise variables that directly characterise the work bout (ie, exercise intensity, exercise duration, type of physical exercise (eg, endurance, resistance or coordinative exercise) and mode of physical exercise (ie, continuous or interval exercise)) is an important prerequisite for a better understanding of the dose-response relationships of acute physical exercise breaks on cognitive performance in general and gaming performance of esports players in particular. The latter assumption is supported by the fact that an explicit focus on density is largely absent in the exercise-cognition literature[39] including studies on esports players. Thus, we propose that investing greater efforts to elucidate the effect of different densities on cognitive performance (including gaming performance) and underlying neurobiological mechanisms (eg, neural efficiency) will add a fruitful nuance beyond FITT to inform the evidence-based prescription of acute physical exercise breaks for esports training.

FUTURE DIRECTIONS ON STUDYING THE INFLUENCE OF DIFFERENT DENSITIES IN ESPORTS

Regarding density, we postulate two approaches to set and study the influence of density.

The first approach can be referred to as 'fixed density', which means that the time intervals between consecutive bouts of acute physical exercise within an esports session are fixed for all individuals (eg, periods of prolonged sitting are interrupted with acute physical exercise breaks after 60 min—as proposed in a narrative review by Baena-Riera *et al*[18]). To investigate the effects of different densities (ie, low vs high density) the duration of the rest bout(s) is manipulated (ie, decreased from 60 to 30 min) while the characteristics of the work bout(s) (ie, exercise characteristics such as type, intensity and duration of the acute physical exercise breaks) need to be held constant.

The second approach can be referred to as 'psychophysiological-informed density', which means that the time after which periods of prolonged sitting in an esports session should be interrupted with acute physical exercise breaks are informed by changes in specific psychophysiological markers (eg, pupil size changes obtained by pupillometry). The latter approach is motivated by the findings of Matsui *et al*[23] who observed a correlation between the decrease in pupil diameter and cognitive performance (ie, executive performance assessed via Flanker task) after 2 hours and 3 hours of esports training. Despite pupil size, other potential psychophysiological candidate markers to inform the timing of acute physical exercise breaks although not without limitations (eg, due to relative lower practicability or reliability)[44] include but are not limited to changes in cortical haemodynamics (eg, assessed via functional near-infrared spectroscopy or transcranial Doppler ultrasound) or heart rate variability because these physiological markers are sensitive to the influence of prolonged sitting[36 37 45] or cognitive fatigue,[46] respectively.

CONCLUSION

In recent years, esports has become popular in many parts of the world contributing to its professionalisation. To achieve or keep a professional status, esports players spend as part of their training routines several hours a day in a sitting and relatively static posture which can increase their risk for negative health events (eg, cardiovascular diseases or overuse injuries) and may decrease the training quality (eg, due to accumulating levels of cognitive fatigue) if not interrupted by acute physical exercise breaks. However, the most effective dosage of acute physical exercise breaks in esports training is unclear necessitating future research. To bridge this gap, we propose that traditional concepts to determine and prescribe the dosage of acute physical exercise breaks (ie, via the FITT principle) should be complemented with the variable density characterising the timing of consecutive bouts of acute physical exercise during an esports session.

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