frontiers

Exploring the relationship between mental wellbeing, exercise routines and the intake of Image and Performance Enhancing Drugs during the COVID-19 pandemic: a comparison across sport disciplines

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Keywords

Excessive exercise, Supplement, IPEDS, COVID-19, enhancement

Abstract

Word count: 349

Introduction: Physical distancing under COVID-19 pandemic had a significant impact on lifestyles, including exercise routines. While adequate levels of exercise promote mental health, excessive exercise needs more consideration. In this study, we examined the relationship between mental health and addictive behaviors, such as excessive exercise and the use of Image and Performance Enhancement Drugs (IPEDs) across twelve sport disciplines.

Materials and Methods: A large cross sectional sample of adult population (N=2,295) was surveyed between April-June 2020 in eight countries. IPEDs use was assessed in conjunction with psychometric measures for problematic exercising (Exercise Addiction Inventory: EAI), appearance anxiety (Appearance Anxiety Index: AAI) and self-compassion (Self-Compassion Scale: SCS). History of addiction, smoking and drinking patterns during physical distancing were also considered. Results were compared across a wide range of sport disciplines, while taking into account the relationship between the psychological measures and IPEDs consumption.

Results: The frequency of IPEDs use was higher among the activity group (AG; 34.6%) than the non-activity group (NAG; 14.6%), although AG participants reported less history of addictions (7.1%) than NAG (11.8%). Logistic regression analysis revealed that scores equal to or above cutoff points, in both the EAI and AAI, predicted IPEDs use. As for differences across the various sport disciplines, those practicing Weight Lifting and Cross Fit were found to be more at risk of excessive exercising and more inclined to use a wide range of IPEDs. Almost of those who scored higher in the AAI also showed a high rate of IPEDs use.

Conclusions: Although exercise could help to increase wellbeing and prevent addictions during COVID-19 pandemic, our results show that those in the AG are particularly vulnerable to excessive IPEDs use. Sports disciplines associated with higher EAI and AAI scores have also shown higher tendency to excessive IPEDs use. Moreover, over the cut-off scores in EAI or AAI could predict IPEDs consumption regardless of the sport discipline. In light of the current findings, it is necessary to better define the “non-excessive” levels of exercise in various sports disciplines and an adequate intake of IPEDs to ensure safety and wellbeing of people during a pandemic.

Contribution to the field

It is novel to investigate a relatively new concept “excessive exercise” in terms of its association with IPEDs use as an enhancement in addition to other addiction-related psychological measures under physical distancing by COVID-19 pandemic, which has influenced on our daily habits dramatically. This study would contribute to mental health promotions by an attempt to find adequate levels of exercises considering both positive and negative aspects of habitual exercises in their associations with other mental health problems, particularly from the perspectives of cross-addiction of excessive exercise with excessive use of substances including IPEDs. Furthermore, it could potentially lead to having knowledge for specific optimizations of adequate exercise habits for health benefits, by examining the differences among various disciplines of exercises. It could shed light on the strategies for having daily exercise habits in “New Normal” under COVID-19.

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Ethics statements

Studies involving animal subjects

Generated Statement: No animal studies are presented in this manuscript.

Studies involving human subjects

Generated Statement: The studies involving human participants were reviewed and approved by University of Hertfordshire Health and Human Science Ethics Committee with Delegated Authority. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Inclusion of identifiable human data

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Keywords: excessive exercise, supplement, IPEDs, COVID-19, enhancement

Abstract

Introduction: Physical distancing under COVID-19 pandemic had a significant impact on lifestyles, including exercise routines. In this study, we examined the relationship between mental health and addictive behaviors, such as excessive exercise and the use of Image and Performance Enhancing Drugs (IPEDs) across twelve sport disciplines.

Materials and Methods: A large cross-sectional sample of adult population (N=2,295) was surveyed. The mean age was 33.09 (SD= 11.40). The number of male participants was 668 (30.0%). IPEDs use was assessed in conjunction with psychometric measures such as the Exercise Addiction Inventory (EAI) and the Appearance Anxiety Inventory (AAI). The participants were grouped into activity group (AG) and non-activity group (NAG) according to the presence or the absence of their exercise habit. Results were compared between these groups, as well as across sport disciplines, while taking into account the relationship between different psychological measures and IPEDs consumption.

Results: The frequency of IPEDs use was higher among AG (34.6%) than NAG (14.6%), although AG participants reported less history of addictions (7.1%) than NAG (11.8%). Logistic regression analysis revealed that scores equal to or above cutoff points, in both the EAI and AAI, predicted IPEDs use. As for differences across the various sport disciplines, those practicing Weight Lifting and Cross Fit were found to be more at risk of excessive exercising and more inclined to use a wide range of IPEDs.

Conclusions: Although exercise could help to increase wellbeing and prevent addictions during COVID-19 pandemic, our results show that those in the AG are particularly vulnerable to excessive IPEDs use. Sport disciplines associated with higher EAI and AAI scores have also shown higher tendency to excessive IPEDs use. Further, the factor of having over the cutoff scores in EAI or AAI in each sport could indicate larger IPEDs consumption regardless of the discipline. In light of the current findings, it is necessary to better define the "non-excessive" levels of exercise in various sport disciplines and an adequate intake of IPEDs to ensure safety and wellbeing of people during a pandemic.

1 Introduction

The COVID-19 pandemic has posed a sudden and unprecedented challenge to public health, leading to dramatic lifestyle changes (Basu et al., 2020; Di Renzo et al., 2020). In this context, exercise could play an important part as a coping strategy to deal with stressful situations. Evidence suggests that regular exercising could have a positive impact on mental health, improving depressive mood, anxiety (Callow et al., 2020; Hervert at al. 2020; Huang et al., 2015; Schuch et al., 2015; Stonerock et al., 2015) and related psychological issues (Hassmén et al., 2000; Schuch et al., 2016). It also helps to improve cognitive and affective functions, such as memory (Parfitt et al., 2000; Suwabe et al., 2018) and attention (de Sousa et al., 2019). Conversely, excessive exercise, known as "compulsive exercise", "problematic exercise" or "exercise addiction", can have a negative influence on mental and physical wellbeing (Berczik et al., 2012; Kreher and Schwartz, 2012). Although excessive exercise has not been formally defined as an addiction in the 5th edition of the Diagnostic & Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association [APA], 2013), the concept has been increasingly debated as part of a wide range of other behavioural, non-drug related forms of addiction, such as gambling, internet use, gaming, eating/ food, sex, and shopping, possibly leading to damaging health consequences, especially among vulnerable groups (Banz et al., 2016; Fineberg et al., 2018; Lichtenstein et al., 2018; Petry et al., 2018).

It is known that exercise and the use of drugs, such as Image and Performance Enhancing Drugs (IPEDs), or licit boosters (e.g., supplements, medicinal products), often coexist as a way to better achieve the ultimate goal in a sport discipline (Peeling et al., 2018). The concept of "enhancement" is defined here as an "intervention aimed to improve the human form and function more than necessary for maintaining health or recovery for purposes other than treating a disease" (Caplan and Elliott, 2004; Juengst at al., 2004). Previous studies have shown that IPEDs are increasingly bought over the Internet without any medical supervision, possibly leading to excessive or even toxic intakes (Corazza et al., 2019; Mooney et al., 2017). For example, the overuse of caffeine tablets could induce negative outcomes, such as insomnia or sudden death (Booth et al., 2020; Ronis et al., 2018; Sweeney et al., 2020), with caffeine use disorder being one of the conditions mentioned in the DSM-5 under a section on "Conditions for Future Study" (Ágoston et al., 2018). It is worth noting that in some cases, licit supplements themselves can contain undisclosed prohibited substances by the World Anti-Doping Agency (WADA) and thus expose users to unwanted health risks (Helle et al., 2019; Mazzoni et al., 2017). Regarding the relationship between excessive physical exercise and IPEDs use, Corazza et al. (2019) indicated that the risk of excessive exercising is positively correlated with IPEDs use. However, both are beneficial to health at low to intermediate levels.

When the COVID-19 pandemic was officially recognised by the World Health Organisation (WHO) in March 2020, it was assumed that the engagement with certain rewarding behaviours, as represented by physical exercise during a period when there was no access to gyms, would have increased considerably as a coping strategy during prolonged periods of self-isolation. Although exercise might have helped to alleviate stress and difficult thoughts at such challenging time, it might also have contributed to a reduced engagement in social interactions and other daily activities, simultaneously facilitating the excessive intake of IPEDs and the development of other risky habits that are then difficult to break. The diffuse advertising of IPEDs on social media and other online platforms (Dubey et al., 2020; King et al., 2020; Kishimoto et al., 2009; Sun et al., 2020) might have made their consumption even more likely when individuals spent more time on the Internet and initiated the consumption among new vulnerable cohorts (Bhatti et al., 2020). Supporting evidence emerged from a recent study on the use of IPEDs among the general adult population (N= 3,161) during COVID-19 pandemic. It was found that 28% of the participants reported a use of such products with 6.4% of them starting a new use during the pandemic (Dores et al., 2021). Interestingly, the only predictor of change in IPEDs consumption was the score on or above the cut-

off point on the Exercise Addiction Inventory (EAI) (OR = 2.272), indicating that excessive exercising could potentially induce excessive IPEDs use at worldwide level (Dores et al., 2021).

However, to date, the differences among sport disciplines in the occurrence of excessive exercising and their association with IPEDs use during the pandemic are still unknown and this is the first study investigating these issues. In this context, we hypothesized that the engagement with exercise and IPEDs use as a coping strategy during the pandemic might have changed significantly across the various sport disciplines. Each speciality is in fact unique in nature and endurance athletes, such as ball game players, fitness centre attendees as well as those engaged in power disciplines have already shown a higher risk of excessive exercising in a pre-pandemic situation (Di Lodovico et al., 2019). We were also interested in assessing the relationship between excessive exercise and different types of psychological functioning such as appearance anxiety (Corazza et al, 2019; Trott et al., 2020) and self-compassion (Neff, 2003) and their differences among various sports. While higher scores in terms of Appearance Anxiety Inventory (AAI) might have been indicative of the individuals being more concerned and critical about their physical appearance during the lockdown, higher scores on Self-Compassion Scale (SCS), a concept which is closely overlapping with mindfulness and Zen Buddhism (Barczak and Eklund, 2020), might have been indicative of the role played by "mind-body" training (Nakao and Ohara, 2014), in developing a safe and a positive attitude towards a challenging situation and in acting as a mitigating factor towards excessive exercise and IPEDs use. For instance, it has been previously found that those practising intensive mind-body training, aimed at achieving a deeper integration between mind (psychology) and body (exercise) (Nakao and Ohara, 2014), such as martial arts players, report a number of cognitive health benefits as a result of their training (Fujiwara et al, 2019).

More specifically, in this study we aimed to investigate the differences in excessive exercising, appearance anxiety, and self-compassion as a related psychological measure between (a) subjects engaged with habitual exercise routines (Activity Group: AG) and non-exercisers (Non-Activity: NAG) and (b) across different sport disciplines. We hypothesized that scores of Appearance Anxiety Inventory and Self-Compassion Scale would significantly be higher in the AG. As for comparisons among different sport disciplines, we hypothesized that several disciplines which demand relatively high-intensity functional training would show higher level of Exercise Addiction Inventory (EAI) and Appearance Anxiety Inventory (AAI).

Besides, we aimed to identify the relevance of IPEDs use in association with above mentioned psychological measures. On this regard, we expected to find a more diffuse use of IPED in AG than in NAG. Finally, we examined the relationships between psychological measures, including excessive exercising, and IPEDs use in both AG and NAG across various sport disciplines.

2 Materials and Methods

2.1 Participants

Overall 2,295 participants participated to the survey. They were from Brazil (*n*=737; 32.1%), Italy (*n*= 647; 28.2%), Spain (*n*= 264; 11.5%), Lithuania (*n*= 224; 9.8%), Portugal (*n*= 177; 7.7%), the United Kingdom (*n*= 129; 5.6 %), Japan (*n*= 70; 3.1%) and Hungary (*n* = 47; 2.0%). The mean age of the sample was 33.09 (*SD*=11.40) with a greater proportion of Female (*n*= 1,607; 70.0%) over Male participants (*n*= 688; 30.0%).

The AG was corresponded to the participants who practiced more than one sport in this investigation. The AG comprised 87.5% (*n* = 2,007) of the respondents. The remaining 12.5% (*n* =

288) were included in the NAG. No difference was found between AG and NAG in age (AG/ NAG, 33.13±11.54/ 32.80±10.39, *t* (2293)= -0.47; *p* =0.642).

As shown in Table 1, they were engaged in a variety of sports, mainly Generic Workout (*n*= 769; 38.3%), Walking (*n*= 387; 19.3%), Weight Lifting (*n*= 355; 17.7%), Runing (*n*= 301; 15.0%), Yoga (*n*= 253; 12.6%), Fighting Sports (e.g. Boxing, Kick boxing, Martial arts) (*n*= 146; 7.3%), Swimming (*n*= 135; 6.7%), Dance (*n*= 128; 6.4%), Martial Arts (*n*= 109; 5.4%), Cycling (*n*= 99; 4.9%), Ball Sports (*n*= 73; 3.6%), Budo (*n*= 67; 3.3%) and Cross Fit (*n*= 63; 3.1%). For clarity reasons, "Generic Workout" included subjects who engaged with some general running, Weight Lifting, and other free body exercises to keep fit and tone the muscles; "Martial Arts" meant oriental (non-Western cultural style) fighting sports; "Budo" corresponded to Japanese-origin martial arts, such as Kendo, Aikido, Judo and Karate.

2.2 Instruments

The study survey covered:

a) demographic information (age, gender, presence of habitual exercise, style of sports);
b) levels of excessive exercising, appearance anxiety, and self-compassion;
c) IPEDs use to enhance fitness performance or to make one's appearance look good before/after physical distancing. The questions were in multiple choice format, and the list of choices consisted of: vitamins, green tea extract, whey protein (for details, see Supplementary Table 1.1-1.4);
d) history of addictions, and any worsening during physical distancing;
e) changes in the amount of drinking and smoking during physical distancing.

2.2.1 Exercise Addiction Inventory (EAI)

We used the EAI to assess the risk of excessive exercising (Terry et al., 2004). The EAI contains six items rated on a five-point scale (e.g. "Exercise is the most important thing in my life"). The total score range is from 6 to 30 with a score ≧24 being indicative of Exercise Addiction. The higher scores indicate a higher risk of Exercise Addiction. The internal reliability of the EAI for the total sample was acceptable (Cronbah's alpha = .685) and the scale has been validated in various nations/translations (Griffiths et al., 2015).

2.2.2 Appearance Addiction Inventory (AAI)

The AAI was used to assess the degree of cognitive processes and behaviors characteristics of body dysmorphic disorder (BDD) (Veale et al., 2014). The AAI is a 10-item questionnaire rated on a 5-point Likert scale (e.g. I check my appearance in mirrors by touching with my fingers or taking photos of myself). The total score range is 0-40 with a cutoff score ≧21 being indicative of a risk of BDD. The higher scores suggest a higher risks of appearance anxiety/BDD. The internal reliability was good (Cronbah's alpha = .87).

2.2.3 Self-Compassion Scale-Short Form (SCS-SF)

The higher scores of SCS indicate more compassion toward oneself, namely, kindness to self. We used the SCS-Short Form in the current study (Raes et al., 2011). This scale has 12-item reflecting on

attitudes towards oneself (e.g. "when something painful happens, I try to take a balanced view of the situation"), resulting in its total scores ranging from 12 to 60. A high internal reliability was observed for the total sample (Cronbach's alpha =.82) and the questionnaire has been translated in different languages (Dores et al., 2021).

2.3 Procedures

The study was approved by the University of Hertfordshire Health and Human Science Ethics Committee with Delegated Authority (ECDA) (aHSK/SF/UH/00104(2)), and by the Ethics Committees of all the participating organizations. This study was conducted according to the Declaration Helsinki (World Medical Association, 2018). All responses were anonymous, securely stored, and made accessible only to members of the research team.

A study questionnaire on "Fitness Lifestyle, Body Image and New Habits During the Corona Virus Pandemic (COVID-19)" was disseminated at the start of the pandemic from April to June in 2020 via the web-based platform Qualtrics (Qualtrics, 2020). Dissemination activities were supported by established laboratories based in eight countries (the United Kingdom, Italy, Lithuania, Hungary, Portugal, Spain, Japan and Brazil), and anonymised data were stored in a secure platform at the University of Hertfordshire. The questionnaires were translated and back-translated from English into Italian, Spanish, Japanese, Portuguese, Hungarian, Lithuanian. The study involved participants aged 18 years over from a broad spectrum of the general population. A 'snowball sampling' technique was employed. It was advertised widely on social media platforms, including Facebook groups (e.g., Fitness and Wellbeing groups), LinkedIn, WhatsApp, Twitter, Instagram, and also on sport-related websites/groups. There were no exclusion criteria. All participants gave written informed consent to participate.

2.4 Statistical analysis

Data were analysed with SPSS Version 22.0.0.0 (IBM, USA). In the analysis of the demographic information, independent samples t-tests and ANOVA were used to examine the continuous variables, and chi-square tests for independence to test categorical variables.

2.4.1 Group Comparison between AG versus NAG

The differences reported by regular exercisers (AG) and non-exercisers (NAG) were assessed. T-tests were applied to compare of EAI, AAI and SCS scores, and chi-square tests were used for the comparisons in terms of IPEDs use, change in the amount of smoking and drinking, and the presence of any addiction history before and after physical distancing. On the chi-square tests, Bonferroni-Corrections were applied for multiple comparisons for data relating to changes in psycho-behavioral measures before and after the COVID-19 pandemic, resulting in a statistical significance $p = .05/6 = .0083$ (the 6 items used were: Use of IPEDs, Initiation of IPEDs use during physical distancing, Increase of smoking during physical distancing, Increase of drinking during physical distancing, History of addiction, Worsening the addiction problem during physical distancing) for each sport discipline.

2.4.2 Group comparison among different kinds of sport disciplines

The ANOVA analysis was carried out to compare the mean EAI, AAI, SCS scores among sport disciplines in which the number of the players was over 3 percent of all subjects. The Tamhane's T2 method was used for post-hoc multiple comparisons as results indicated not equal variances (i.e. heteroscedasticity) among various sport disciplines for the EAI and AAI scores. With equal variances in the SCS scores the Tukey post hock procedure was performed for multiple comparisons. In addition, chi-square tests were used for the comparisons regarding the presence of IPEDs use, change in the amount of smoking and drinking, and any addiction history before and after physical distancing. The comparisons were performed between one of the disciplines and others. The Bonferroni-corrections were applied for multiple comparisons for the data which related to the changes in psycho-behavioral measures before and after COVID-19 pandemic after chi-square tests (statistical significance *p*- values were set at .05/5= .01, 5 items were: Usage of IPEDs, Increase of smoking during physical distancing and Increase of drinking during physical distancing, History of addiction, Worsening the addiction problem during physical distancing).

2.4.3. Logistic regression between psychological indices (EAI, AAI and SCS) and IPEDs use

Logistic regression analyses were performed to investigate how the EAI, AAI and SCS predict IPEDs use in both the AG and the NAG and across the investigated sport disciplines. The response variable was the usage of IPEDs (classified as 0, “not used ”or 1, “used”), while the explanatory variables were age, gender (classified as 1, “Male participants” or 2, “Female participants”), equal to or above cutoff points in the EAI and AAI (classified as 0, “under the cutoff points” or 1, “equal or above cutoff points”) and total scores of the SCS.

3. Result

3.1. Psychological measures

The average scores for the whole samples were: *M*= 16.52; *SD*= 4.16 (EAI), M= 16.84; *SD*= 5.55 (AAI), and *M*= 30.9; *SD*= 6.02 (SCS), 736 (32.1%) individuals used IPEDs. The numbers of those who scored over cutoff of EAI or AAI were 96 (4.2%) (EAI ≧24) and 480 (20.9%) (AAI ≧21).

3.2. Addiction and increase of smoking and drinking

History of addictions was reported among 7.7% (*n*= 176) of the participants with most of the sample (*n*= 2,119; 92.3%) having no previous addiction history (Table 2). The habitual smokers (*n*= 471; 20.5%), 37.2% (*n*= 175) felt the need to smoke more during physical distancing, while habitual drinkers (*n*= 1934; 84.3%), 16.8% (*n*= 325) felt the need to increase the consumption of alcohol during physical distancing.

3.3. Group comparisons between activity group (AG) versus non-activity group (NAG)

The group comparisons between the different sport disciplines are shown in the Supplementary Table 2-4 and schematically summarized in Fig. 1. Differences within groups of different sport disciplines, including NAG, were also observed for EAI, F (15, 3032) = 8.11, $p < .001$. Tamhane's T2 method based post-hoc analysis showed the EAI in walking to be considerably lower in comparison to the other sport disciplines ($ps < .009$), while Weight Lifting ($ps < .02$) and Cross Fit ($ps < .03$) had higher EAI scores in comparison to other sport disciplines. Differences within groups of sport disciplines including NAG were also observed for AAI, F (16, 3319) = 6.98, $p < .001$. For this group's Tamhane's T2 test revealed Budo ($ps < .02$) and Cycling ($ps < .03$) AAI scores to be lower comparing to other sport disciplines. While Weight Lifting ($ps < .05$), Cross Fit ($ps < .04$) and Dance ($ps < .04$) reached higher AAI scores compared to the other sport disciplines.

There was a tendency for SCS scores to differ across sports disciplines including NAG F (16, 3319) = 1.64, $p = .052$.

Some sports showed significantly higher, or lower, percentages in IPEDs user than other disciplines. More specifically, IPEDs use was significantly higher in Weight Lifting (n= 217; 61.1%), χ^2(2, n=694)= 134.37; $p< .001$ and Cross Fit (n= 38; 60.3%), χ^2(2, n=694)= 19.047 $p< .001$., while it was significantly lower in Walking (n= 95; 24.5%), χ2(2, n=694)=21.33; $p< .001$, than in other disciplines. The rate of subjects who had history of addiction and subjects who experienced worsening of it during physical distancing did not differ among all disciplines. The rate of those who have increased in smoking was higher in Fighting Sports (n= 13; 61.9%), χ2(2, n=123)= 7.75; $p = .005$, but lower in Weight Lifting (n= 9; 17.3%), χ^2(2, n=123)= 7.52; $p = .006$ and those who have increased in drinking was lower in Generic Workout (n= 92, 12.0%), χ^2(2, n=297)= 7.95; $p = .005$.

3.4. Logistic regressions between EAI, AAI and SCS, and IPEDs use

The logistic regression analyses revealed that being equal to or above cutoff points in the EAI predicted IPEDs use in the AG (OR = 2.226, 95% C.I. [1.438-3.444], $p = .000$) (Supplementary Table 5). Being equal to or above of AAI's cutoff points also predicted IPEDs use in the AG (OR = 2.009, 95% C.I. [1.571-2.571], $p = .000$). Female Gender also predicted IPEDs use in the AG (OR= 0.614, 95% C.I. [0.502-0.750], $p < .001$).

Regarding the analyses of each kind of discipline, being equal to or above EAI's cutoff points predicted IPEDs use in Generic Workout (OR = 2.047, 95% C.I. [1.013-4.135], $p = .046$), Yoga (OR = 9.805, 95% C.I. [1.969-48.824], $p = .005$) and Fighting Sports (OR = 12.984, 95% C.I. [1.461-115.410], $p = .021$). Being equal to or above AAI's cutoff points also predicted IPEDs use in Generic Workout (OR= 1.604, 95% C.I.[1.066-2.413], $p = .023$), Walking (OR = 2.214, 95% C.I. [1.166-4.201], $p = .015$), Weight Lifting (OR = 2.104, 95% C.I. [1.210-3.658], $p = .008$), Runing (OR= 2.061, 95% C.I.[1.070-3.974], $p = .031$), Fighting Sports (OR = 3.219, 95% C.I. [1.144-9.058], $p = .027$) and Dance (OR= 2.872, 95% C.I. [1.096-7.521], $p= .032$). SCS scores did not predict IPEDs use in any discipline. Female gender also predicted IPEDs use in Generic Workout (OR= .391, 95% C.I.[0.275-0.555], $p= .000$) and Weight Lifting (OR= 0.631 95% C.I.[0.401-0.993], $p= .047$).

4. Discussion

Although excessive exercising has been previously correlated with excessive IPEDs use during the COVID-19 physical distancing (Dores et al, 2021), this is the first study assessing the differences across various sport disciplines in terms of excessive exercise (EAI), appearance anxiety (AAI), and self-compassion (SCS) and their level of engagement in physical activity (AG vs NAG).

Overall we found that the AG group reported a higher IPEDs use, but was less affected by history of addictions compared to the NAG. In addition, the group comparison between AG and NAG revealed that neither the mean scores of AAI nor SCS differ in AG from those in NAG. These results could support the findings of a previous study that appearance anxiety and self-compassion were non-significant predictors of habit of physical exercise (Dores at al., 2021), while less history of addictions in the AG indicates that habitual exercise may have health benefits in preventing addictions in general.

Results of the EAI and the AAI varied significantly among various sport disciplines (Supplementary Table 2, 3). As indicated in Figure 1, we categorized the sports into three groups according to the levels of EAI: (1) high EAI group; (2) low EAI group; (3) others. Weight Lifting, and Cross-Fit corresponded to the high EAI group. Only Walking corresponded to the low EAI group. These results confirms previous evidence (Di Lodovico et al., 2019), according to which endurance athletes, ball game players, fitness centre attendees, and those engaged in power disciplines have a high risk of excessive exercising. It is worth noting that in those reporting a high score in the EAI, Weight Lifting and Cross Fit also showed a higher IPEDs use. Conversely, a sport discipline in low EAI group, that is, Walking, was significantly associated with lower rate in IPEDs use. Those who perform Weight Lifting often pursue strength and muscle hypertrophy. However, when the training becomes obsessive and compulsive, it could lead to Muscle Dysmorphia (Maida and Armstrong, 2005; Mosley, 2009). Since CrossFit is recognized as a kind of high-intensity functional training with high risk of excessive exercise (Claudino et al., 2018; Lichtenstein and Jensen, 2016), this sports could have some traits in common with Weight Lifting. Consequently, it could be suggested that "the higher the EAI, the higher the IPEDs use" indicates that excessive exercising is associated with the risk of cross-addiction with other substance intake. Actually, it was proposed that 15% of those at-risk for excessive exercising may have co-occurring substance addictions, such as nicotine and alcohol addictions (Sussman et al., 2011), although this was not confirmed by other investigations (Szabo et al., 2018). Still, the fact that 12.2 % of our sample purchased IPEDs over the Internet, might be indicative of a cross-addiction in some individuals, especially when exposed to excessive Internet use during the COVID-19 pandemic (Sun et al., 2020). In other words, the co-occurrence of IPEDs and excessive Internet use during COVID-19 pandemic has forced individuals to change their lifestyle drastically, leading in some cases to the development of new risky behaviours, which might then be difficult to break.

Some interesting results also emerged in terms of self-compassion, which has been previously associated with high coping skills and athletes' motivation towards their training in sports (Barczak and Eklund, 2020). High level of self-compassion has also inversely been related to the risk of substance use disorder, such as alcohol and cannabis (Phelps et al., 2018; Wisener and Khoury, 2020). In our study, of particular relevance was the case of Cycling, in which this sport discipline reported higher SCS and lower AAI scores. Although more studies across different level of training are required, the current findings might suggest that high self-compassion might have contributed to lower AAI and adequate engagement in Cycling. As a suggestion, more targeted "mind-body" training programmes, involving the cultivation of self-compassion, could play an important role in improving coping skills or reducing the risk of substance use disorder and act as a meaningful addiction.

Regarding the finding in logistic regressions, a higher rate in IPEDs use in AG, together with a significant prediction of IPEDs use by being equal to or above cutoff level of EAI and AAI in AG, indicates potential risks of exercise for IPEDs use. Furthermore, we found that the score of EAI and AAI above the cutoff predicted IPEDs use in AG. This finding is in line with the previous report before the occurrence of COVID-19 pandemic (Corazza et al., 2019). Pathological levels of excessive exercising and appearance anxiety could be risk factors for excessive IPEDs use, indicating that it would be meaningful for individuals with high EAI and/or AAI to be aware of the risks of the "excessive enhancement" by IPEDs use. They would have to pay attention to the strategies of approaching each activity, such as checking the risk of burnout and compulsiveness with the exercises from subjective, together with objective points of view (Kreher and Schwartz, 2012; Weinstein and Weinstein, 2014). Also, Logistic regression analysis revealed that being equal to or above cutoff of points of EAI or AAI predicted IPEDs use in seven out of 13 kinds of disciplines. A possible interpretation is that, those who have apparent tendency for either excessive exercise or appearance anxiety could have a high risk of excessive IPEDs use, regardless of what discipline of exercise people are engaged in.

There are several limitations in the current study. Firstly, the number of subjects scoring equal or above the cutoff points of EAI and AAI was small. Therefore, further research would be needed to further clarify the the relationship between excessive exercising and IPEDs use in larger samples. Secondly, the internal reliability of the EAI is low, but we adopted that measure because this study was exploratory. Thirdly, the changes of the EAI and AAI before, during and after the pandemic were not examined in this study. Therefore, causal relationships among these measures were still unclear. A longitudinal study would be expected to be performed during the time course: before, current, and after this pandemic. Fourthly, the interpretations of the results should be cautious because of the discrepancy in gender valance. Finally, the types of sports disciplines should be expanded, for example, dividing ball sports into specific disciplines such as baseball, football and table tennis in order to clarify the characteristics of each disciplines more precisely, such as tendency of falling into excessive exercise or IPEDs use.

While for mental health benefits of exercise in general, our study showed how excessive exercising could potentially be associated with excessive IPEDs use, which may contribute to further negative outcomes during COVID-19 pandemic. It is worthwhile paying attention to the risks associated to IPEDs consumption particularly in individuals with traits of excessive exercising, or appearance anxiety, particularly in disciplines which demands high-intensity functional training who emerged to be most at risk. At the same time, those who are more vulnerable to develop excessive exercising patterns, or manifest appearance anxiety, could be more prompt to use IPEDs regardless from the discipline of practice. As the global COVID-19 pandemic persists, longitudinal studies would be needed to examine the causal relationship between exercise habits and IPEDs use over a longer period of time.

Overall our study shed new light on the relatively new concept of "Excessive exercising" and its association with IPEDs use and related psychological measures among different sport disciplines at the start of the COVID-19 pandemic, which has influenced our daily habits dramatically. Findings emerging from our work suggest the need for more balanced mental health promotion strategies in terms of both positive and negative aspects of habitual exercise and their associations with other mental health conditions, particularly in regard to the overlooked cross-addiction between excessive exercising and overuse of substances, including IPEDs. It has also a strong relevance in terms of doping prevention as we were able to identify the diffuse intake of IPEDs among amateur athletes of defined sport disciplines, thus contributing to "clean and fair play" according to the definition of anti-

doping provided by WADA. Finally, it contributes to a more informed discussion on what constitutes "good exercise habits" in terms of health benefits among various exercise forms during exceptional circumstances such as the current COVID-19 pandemic. Because of the implementation of physical distancing measures, the lifestyles and the coping strategies adopted by people with addiction have drastically changed. While face-to-face services have played an important role in supporting these individuals before the pandemic, might now consider alternative forms of intervention, such as telephone and Virtual Reality-based programs which have been developed during the pandemic (Liese and Monley, 2021). Excessive exercising (and the related excessive IPEDs consumption) may be prevented by these newly established strategies for health services.

3 Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

4 Author Contributions

Conceptualization: HF and OC. Methodology: HF, OC and MS. Formal analysis: JB. Investigation and data collection: MS, JB, AD, KK, PS, IL, DC, VG, IC, FB, SM, TM, MG-M, ZD, KA, AS, AV, EA-A, RS-L, IB-G, AP, GB, HF. Resources: HF and OC. Data curation: HF, MS, JB and OC. Writing-original draft preparation: MS. Writing-review and editing: KK, SY, AD, FB, ZD, AS, IL, HF and OC. Visualization: MS and KK. Supervision: MS, HF and OC. Project administration: OC. Funding acquisition: HF and OC. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. The datasets .

Table 1. *Type of activities(N= 2295)*

Generic Workout	38.3%
Walking	19.3%

Weight Lifting	17.7%
Runing	15.0%
Yoga	12.6%
Fighting Sports	7.3%
Swimming	6.7%
Dance	6.4%
Martial Arts	5.4%
Cycling	4.9%
Ball Sports	3.6%
Budo	3.3%
Cross Fit	3.1%
Mountain	2.9%
Tennis	1.7%
Triathlon	0%
Other	3.7%
None activity	12.5%

Generic Workout: some general running, Weight Lifting, and other free body exercises to keep fit and tone the muscles

Martial Arts: oriental (non-western cultural style) fighting sports, such as Kendo, Judo, Aikido, Karate, Taekwondo, Brazialian jiu-jitsu, Muay Thai, Wushu, Tai Chi and Capoeira

Budo: Japanese-origin martial arts, such as Kendo, Judo, Aikido and Karate

Table 2. *Rate of addiction, an increase of smoking and drinking (N= 2295)*

History of Addiction	N(%)

Yes	176 (7.7%)
No	2119 (92.3%)
Increase during	49 (27.8%)
Increase of smoking	**N(%)**
No increase	296 (62.8%)
Increase	175 (37.2%)
Increase of drinking	**N(%)**
No increase	1609 (83.2%)
Increase	325 (16.8%)

Table 3. *Differences in IPEDs use and behavioural changes between AG and NAG*

	NAG	**AG**	
Usage of IPEDs	42 (14.6%)	694 (34.6%)	**χ^2 = 46.22; p<0.001**
Start of IPEDs during physical distancing	10 (3.9%)	102 (7.2%)	χ^2 = 3.78; *p* =0.052
Increase of smoking during physical distancing	52 (47.7%)	123 (34.0%)	χ^2 = 6.76; *p* =0.009

Increase of drinking during physical distancing	28 (9.7%)	297 (14.8%)	$\chi^2 = 5.34$; $p = 0.021$
History of addiction	34 (11.8%)	142 (7.1%)	**$\chi^2 = 7.96$; $p = 0.005$**
Worsening the addiction problem during physical distancing	7 (20.6%)	42 (29.6%)	$\chi^2 = 1.10$; $p = 0.294$

Abbreviations: AG= activity group, NAG=non-activity group.

According to Bonferroni correction, all p's which are lower than .0083 should be considered significant.

Figure 1.JPEG

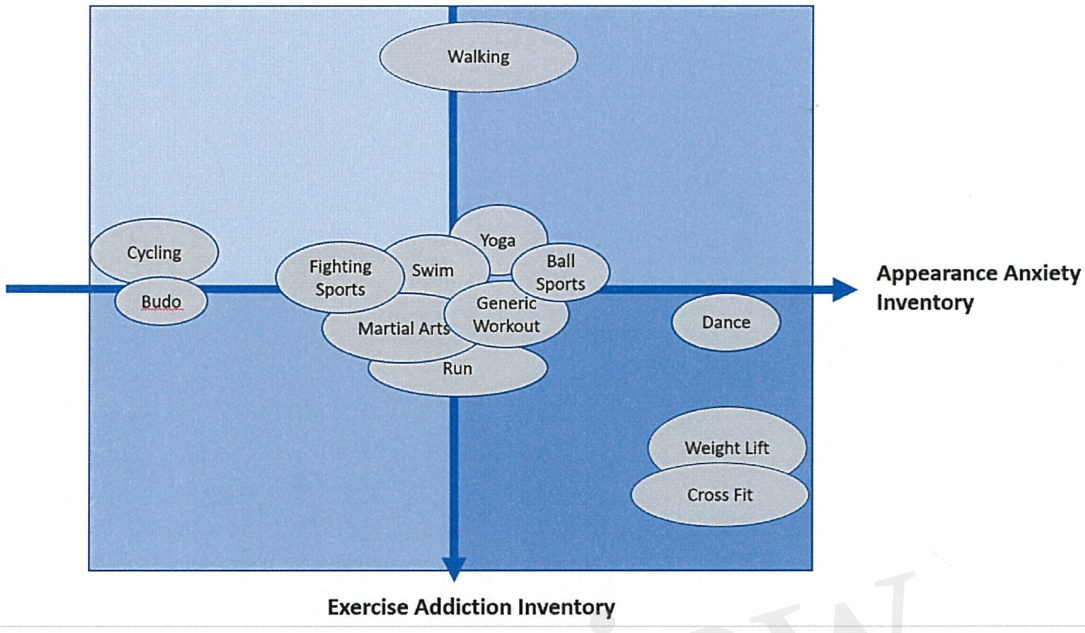

Fig.1 Schematic representation of the features of EAI and AAI on each exercise