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RESEARCH

The anthropometric profile and body composition of youth soccer goalkeepers after the COVID-19 pandemic, according to the maturity offset

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Abstract

Purpose To investigate the anthropometric profile of youth soccer goalkeepers in relation to the maturity offset after the COVID-19 pandemic.

Methods Forty-two young male goalkeepers took part in the study. The anthropometric profile and body composition were assessed through the anthropometric method and the peak height velocity (PHV) was estimated. Participants were classified as pre-PHV ($n = 16$, age $= 11.31 \pm 0.94$), circa-PHV ($n = 7$, age $= 13.27 \pm 1.02$) and post-PHV ($n = 19$, age $= 16.86 \pm 2.00$).

Results The adiposity was significantly higher in pre-PHV goalkeepers than circa- and post-PHV and in circa-PHV than in post-PHV, according to BMI ($p = 0.017$), the percentage of fat mass ($p < 0.001$) and the fat mass index ($p = 0.023$). Compared with similar sample in literature assessed before the COVID-19 pandemic, the pre-PHV subgroup showed a higher prevalence of children at abdominal obesity risk (62.5 vs. 33.3%).

Conclusion The current study shows a relationship between the maturity offset and goalkeepers' anthropometric profile. The COVID-19 pandemic seemed to affect the abdominal obesity risk of pre-PHV children.

Keywords Youth sports · Peak height velocity · Adiposity · Relative age effect · Growth spurt · Maturation

Introduction

The recent COVID-19 pandemic affected several aspects of individuals' lifestyles, including physical activity and sports participation. After the first wave of infections, most countries adopted a partial or a complete lockdown to limit the contagion. As a result, the confined people had to adapt to the new conditions, determining changes in their physical activity habits. In some regions, self-reported physical activity was consistent with the maintenance of an active lifestyle [1] Conversely, other studies indicated a reduction in physical activity levels and the increase of sedentary behaviors in various subgroups, such as adults, older people, children, adolescents [2, 3], and athletes [4]. Furthermore, physical activity levels persisted low even after the first wave of the COVID-19 pandemic [5].

In recent years, attention has been put on children and adolescents' lifestyle, in terms of nutrition and physical activity, even when they participate in sports. In particular, sports participation might not be sufficient to reach the recommended levels of physical activity for children [6, 7] and there is also evidence that children and adolescents participating in sport may have an excess of adiposity [7].

Before the COVID-19 pandemic, we demonstrated a significant prevalence of overweight, obesity, and central adiposity in young soccer goalkeepers, assessed in July 2019 [8]. Soccer goalkeepers are the only players allowed to touch the ball with hands. They are taller and heavier than outfield players and have higher fat mass at youth and elite levels [9–11]. Coaches may select early heavier and

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taller players to particular positions, such as goalkeeper and central defense because this gives an advantage in the goal area. Thus, the awareness of effective training programs and fitness monitoring of developing young goalkeepers is an emerging field, and following rule changes, like the “back pass” and the “6 s release” rules, became even more important. Indeed, goalkeepers cover larger areas of the pitch than in the past, sprint more, and show better skills in controlling the ball with their feet.

Some athletic populations worsen their body composition during or after the COVID-19 pandemic lockdown due to the restriction measures that limited physical activity engagement [12, 13]. However, these studies are generally limited to adults examined for short periods, such as the detraining suffered during the competition break. No studies compared young athletes exposed for longer periods to the COVID-19 restriction measures with previous samples not exposed to social and physical restrictions.

Thus, the present study aimed to investigate the anthropometric profile and body composition of a sample of youth goalkeepers who experienced the COVID-19 restriction measures and compare it with a similar sample in terms of sample size, mean age, method of recruitment and origin, and assessment who were assessed before the COVID-19 pandemic [8]. We hypothesize that the current sample would show higher adiposity values than the previously published one and that the sample in the present study would comprise more overweight/obese individuals.

Methods

Participants

In July 2022, forty-two young male goalkeepers (age 14.15 ± 2.99) were recruited from different soccer teams during a training camp dedicated to youth goalkeepers. Participants were classified into three subgroups: pre-PHV, circa-PHV, and post-PHV. All participants were involved in soccer as goalkeepers for at least one year and performed 3–5 training sessions per week ($n = 3.6 \pm 1.08$). The study was conducted in accordance with the Declaration of Helsinki. All individuals gave their assent to voluntarily take part in the study and delivered written informed consent to parents for permission to participate, while the technical staff approved the conduct of the study. Nonetheless, the present data arose as a condition of the monitoring procedures performed during the training camp. Because of the retrospective nature of the analyses without interfering with the training routine, usual appropriate ethics committee clearance was not required [14]; nevertheless, all physical performance data were anonymized before analyses to ensure player confidentiality.

Anthropometry and body composition

All the anthropometric measurements were performed by a certified specialist (i.e., a level 1 certification of the International Society of the advancement of Kinanthropometry, ISAK). Participants wore light clothing and had fasted for at least 12 h before the assessments. Height and sitting height were measured to the nearest 0.1 cm using a stadiometer (GPM, Zurich, Switzerland) and a $30 \times 40 \times 50$ cm high wooden anthropometric box and sitting height to height ratio (SH/Hr) was obtained. Body weight was measured to the nearest 0.1 kg using a stadiometer with a balance-beam scale (SECA 770, Seca, Hamburg, Germany). Waist circumference (WC) was measured to the nearest 0.1 cm using a Cescorf anthropometric tape (Cescorf, Porto Alegre, Brazil). The percentage of fat mass (%FM) was calculated according to Brambilla [15] and fat mass in kilograms (FM) was derived. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height, expressed in meters. Thus, the BMI > 85th percentile was used to classify the participants as normal weight and overweight/obese [16]. Fat mass index (FMI) and fat-free mass index (FFMI) were calculated as fat mass and fat-free mass weight in kilograms, respectively, divided by the square of height, expressed in meters. According to McCarthy’s waist circumference cut-points, participants with a WC > 90th percentile were considered to have abdominal obesity [17]. Waist-to-height ratio (W/Hr) > 0.5 identified those participants at higher cardiometabolic risk [18].

Age and maturity status

The maturity offset was defined according to the Mirwald equation based on the distance from peak height velocity (PHV) in years (YPHV), and derived from height, sitting height, and leg length as somatic dimension, the chronological age, and their interaction [19]. Thus, participants were classified into three subgroups according to their YPHV: pre-PHV (offset < -1 year), circa-PHV ($\leq \pm 1$ year), and post-PHV (offset $> +1$ year), as a previous study reported [8]. Considering that the YPHV may differ significantly between participants, they were further divided into three subgroups according to maturity offset velocity (early, average, late maturer). The predicted adult height (PAH) and the percentage of predicted adult height (%PAH) were estimated according to the Sherar method [20]. Finally, to evidence the occurrence of a selection bias based on the relative age effect, the date of birth was used to define the quartile of birth and months from one to six and from seven to twelve, respectively, were merged into two categories (first/second vs. third/fourth) [21].

Pre-COVID-19 pandemic sample evaluation

Regarding the previously evaluated sample, information on sample recruitment, anthropometry, body composition and maturity assessment can be found elsewhere [8] and we followed the same procedure, as reported in the present study.

Statistical analysis

The Shapiro–Wilk test was performed to check the normality of the data. When data were normally distributed, the analysis of variance (ANOVA) was used to determine the differences between the maturity status subgroup (defined as fixed factor) in body composition and anthropometric parameters (defined as dependent variables), and partial eta squared (η^2_p) was calculated to indicate the effect-size (small = 0.01, medium = 0.06; large = 0.14). When the analysis of variance (ANOVA) showed significant results, Tukey's post hoc test was used to confirm where the difference occurred. Pearson's correlation coefficient was used to determine the extent of correlation between YPHV and anthropometric measures. The magnitude of correlations was considered as: $r = 0.00$–0.09, negligible; $r = 0.10$–0.39, weak; $r = 0.40$–0.69, moderate; $r = 0.70$–0.89, strong; $r = 0.90$–1.00, very strong [22]. When data were not normally distributed, the Kruskal–Wallis with Dunn's post-hoc test was used instead of ANOVA and Tukey's post hoc, respectively, and Spearman's Rho was used instead of Pearson's. Considering we did not meet the conditions to run the Pearson chi-square (χ^2) test for independence to check the association between maturity status and the identified categories, the number of individuals and frequencies were calculated, as well as the odds ratio for each pair of subgroups. The comparison against previously published values (July 2019 Vs. July 2022) was computed using the One sample t test or the Wilcoxon signed-rank test when data were not normally distributed. Descriptive data are presented as mean ± standard deviations, while categorical data as frequency. The statistical significance was set at < 0.05.

Results

Anthropometric profile and body composition

Table 1 shows descriptive statistics for anthropometric and body composition variables and subgroup comparisons for maturity offset. Age, height, weight, sitting height, the

Table 1 Descriptive data of goalkeepers based on maturity status

	Pre-PHV ($n = 16$) M ± SD	Circa-PHV ($n = 7$) M ± SD	Post-PHV ($n = 19$) M ± SD	Statistic	p	η^2_p
YPHV (years)[a,b,c]	− 2.08 ± 0.83	0.36 ± 0.66	2.90 ± 1.41	34.360	< 0.001†	–
Age (years)[a,b,c]	11.31 ± 0.94	13.27 ± 1.02	16.86 ± 2.00	57.700	< 0.001	0.750
Height (cm)[a,b,c]	151.25 ± 8.29	164.24 ± 6.97	179.76 ± 6.61	30.831	< 0.001†	–
Weight (kg)[a,b,c]	44.75 ± 9.35	58.36 ± 10.14	72.26 ± 9.09	37.152	< 0.001	0.659
Sitting height (cm)[a,b,c]	77.38 ± 4.27	84.79 ± 2.64	93.79 ± 3.09	33.471	< 0.001†	–
SH/Hr[b]	0.51 ± 0.01	0.52 ± 0.01	0.52 ± 0.02	5.906	0.052†	–
WC (cm)[a,b]	66.26 ± 5.98	73.40 ± 8.66	76.39 ± 5.48	11.592	< 0.001	0.373
W/Hr	0.44 ± 0.04	0.45 ± 0.06	0.43 ± 0.03	1.198	0.549†	–
PAH (cm)	181.89 ± 5.41	177.88 ± 7.80	182.19 ± 5.84	1.405	0.257	–
%PAH (%)[a,b,c]	83.14 ± 3.27	92.40 ± 3.38	98.66 ± 1.39	34.087	< 0.001†	–
BMI (kg/m^2)[b]	19.44 ± 2.93	21.68 ± 3.93	22.34 ± 2.41	4.520	0.017	0.188
FM (kg)[b]	8.30 ± 1.74	9.95 ± 1.40	9.96 ± 1.40	4.916	0.012	0.201
%FM (%)[a,b,c]	18.56 ± 0.92	16.99 ± 1.14	13.86 ± 1.66	32.271	< 0.001†	–
FMI[b,c]	3.62 ± 0.63	3.71 ± 0.91	3.09 ± 0.48	4.180	0.023	0.177
FFMI[b]	15.83 ± 2.33	17.96 ± 3.03	19.25 ± 2.13	9.132	< 0.001	0.319

Data are expressed as mean ± standard deviation

Pre-PHV pre-peak height velocity, Circa-PHV circa-peak height velocity, Post-PHV post-peak height velocity, YPHV years from peak height velocity, SH/Hr sitting height to height ratio, WC waist circumference, PAH predicted adult height, %PAH percentage of predicted adult height, BMI body mass index, FM fat mass, %FM percentage of fat mass, FMI fat mass index, FFMI free fat mass index, W/Hr waist-to-height ratio

[a]Indicates statistical significance for pre-PHV vs. circa-PHV

[b]Indicates statistical significance for pre-PHV vs. post-PHV

[c]Indicates statistical significance for circa-PHV vs. post-PHV

†Indicates Kruskal–Wallis results

percentage of predicted adult height (%PAH), and %FM were significantly different between the three subgroups. Sitting height to height ratio (SH/Hr), BMI, FM, and FFMI significantly differed between pre-PHV vs. post-PHV subgroups. The WC was significantly different between pre-PHV vs. circa-PHV and post-PHV subgroups. The FMI was significantly different between circa-PHV vs. post-PHV and pre-PHV vs. post-PHV subgroups. Finally, the predicted adult height (PAH) and the W/Hr were not different between subgroups.

Correlation between years from peak height velocity (YPHV), anthropometric measures, and body composition

Table 2 shows the correlation between YPHV and the anthropometric and body composition values. Briefly, a positive, very strong correlation was found with height, sitting height, and %PAH; A positive, strong correlation was found with weight; a positive, moderate correlation was found with WC, BMI, and FFMI; a positive, weak correlation was found with SH/Hr and FM; A negative, very strong and a negative, moderate correlation were found with %FM and FMI, respectively. Finally, no correlations were found with W/Hr and PAH.

Table 2 Correlation between YPHV and anthropometric measures

Selected variables	Correlation with YPHV (Pearson's *r* or Spearman's Rho)	*p*
Height (cm)	0.920†	< 0.001
Weight (kg)	0.866	< 0.001
Sitting height (cm)	0.957†	< 0.001
SH/Hr	0.355†	0.021
WC (cm)	0.625	< 0.001
W/Hr	– 0.145†	0.360
PAH (cm)	0.112	0.482
%PAH (%)	0.995†	< 0.001
BMI (kg/m^2)	0.450	0.003
FM (kg)	0.361	0.019
%FM (%)	– 0.948†	< .001
FMI	– 0.447	0.003
FFMI	0.610	< 0.001

YPHV years from PHV, SH/Hr sitting height to height ratio, WC waist circumference, PAH predicted adult height, %PAH percentage of predicted adult height, BMI body mass index, FM fat mass, %FM percentage of fat mass, FMI fat mass index, FFMI free fat mass index, W/Hr waist-to-height ratio

†Indicates Spearman's Rho

Categories comparison

Figure 1 shows the number of individuals and frequencies for each category while Table 3 shows the odds ratio and 95% confidence interval for each pair of subgroups.

Comparison with published data

In previously published data, there were twelve pre-PHV, fourteen circa-PHV, and sixteen post-PHV goalkeepers [8]. In the present study, we found sixteen pre-PHV, seven circa-PHV, and nineteen post-PHV goalkeepers. We also found lower SH/Hr and W/Hr in the pre-PHV subgroup ($W = 8.0$, $p = 0.007$; $W = 17.0$, $p = 0.014$, respectively) and higher YPHV, age, %PAH, and WC in the post-PHV subgroup ($W = 160$, $p = 0.042$; $t = 2.768$ (19), $p = 0.012$; $W = 185$, $p = 0.003$; $t = 1.911$ (19), $p = 0.036$, respectively) compared to previously published values. Table 4 shows the comparison between the current and the previous sample, while the descriptive data of the anthropometric and maturity characteristics of the latter were published elsewhere [8].

Discussion

The current study shows a relationship between the maturity offset and goalkeepers' body composition; pre-PHV children showed higher %FM and FMI values than the circa-PHV and post-PHV; the circa-PHV subgroup showed higher FMI than post-PHV, and the latter showed higher FFMI values. These results are equivalent to those we previously published on a similar sample assessed before the COVID-19 pandemic [8], although some differences emerged. First, we found higher WC in the current post-PHV subgroup than in the previous assessed before the COVID-19 pandemic. Second, although the present pre-PHV subgroups showed lower W/Hr values, we found a higher probability of children with abdominal obesity than the pre-PHV sample assessed before the COVID-19 pandemic (62.5 vs. 33.3%; odds ratio = 3.332). Several studies indicated that the pandemic dramatically affected physical activity levels worldwide [2, 3, 5]. Furthermore, some studies evidenced as body composition worsened during this period [12, 13]. Thus, according to our hypothesis, the impact of the COVID-19 restrictions on the physical activity behaviors of participants may have determined such differences. Unfortunately, we are not able to establish a causal relationship between the adiposity of the investigated sample and the COVID-19 restrictions due to the lack of physical activity measures.

In the present study we confirmed the observation that the younger are the goalkeepers, according to the maturity offset, the higher is the adiposity [8]. This condition may be related to the maturation process and an early selection of

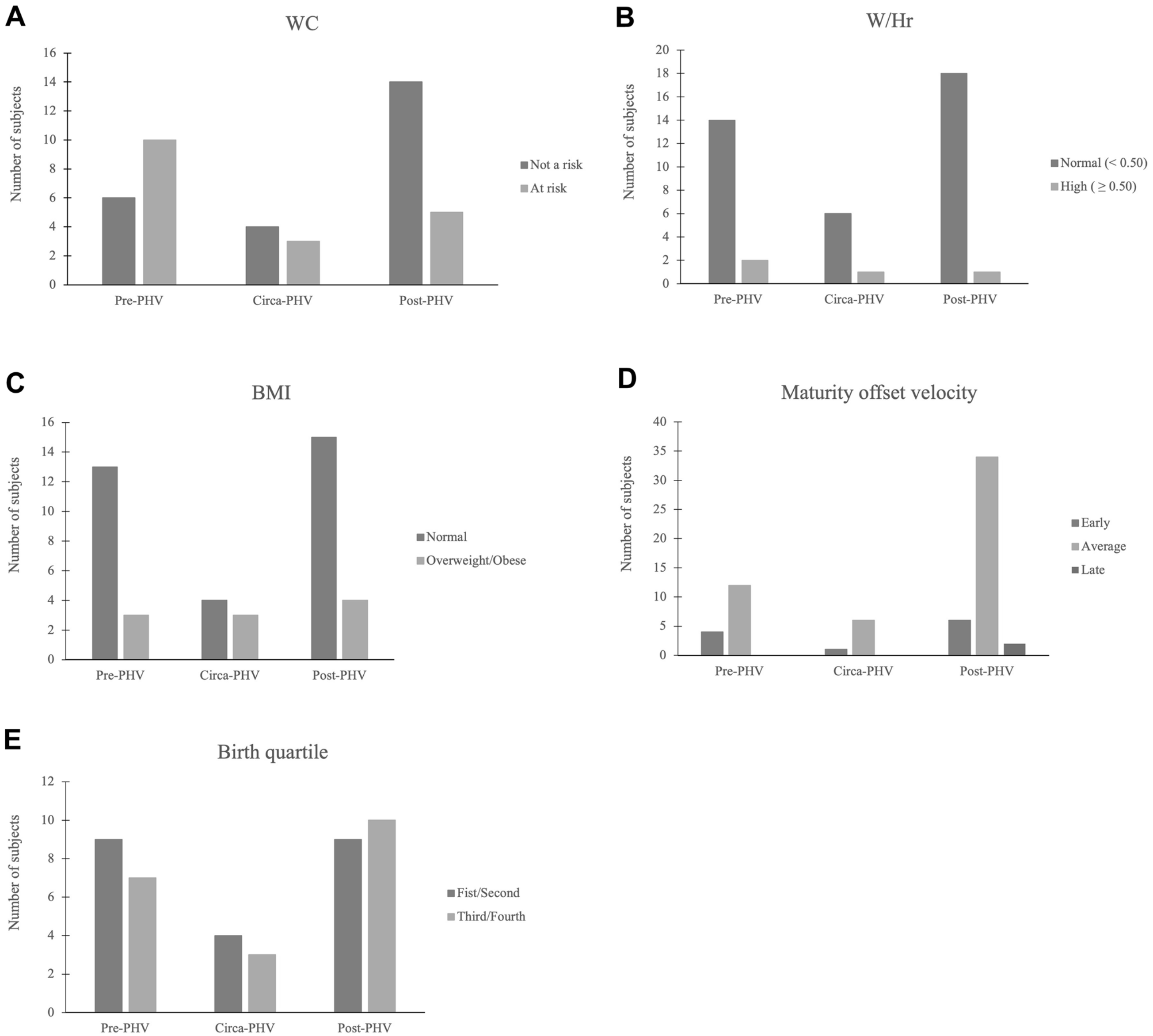

Fig. 1 Association between goalkeepers' subgroups based on maturity offset and **a** WC, **b** W/Hr (%FM), **c** BMI, **d** achievement of peak growth, and **e** birth quartile. BMI body mass index, WC waist circumference, W/Hr waist-to-height ratio, %FM percentage of fat mass

Table 3 Odds ratio for each pair of subgroups

	Odds ratio (95% CI)		
	Post-PHV vs. pre-PHV	Post-PHV vs circa-PHV	Circa-PHV vs. pre-PHV
WC	0.21 (0.05, 0.9)	0.48 (0.08, 2.92)	0.45 (0.07, 2.74)
BMI	1.16 (0.22, 6.15)	0.36 (0.06, 2.28)	3.25 (0.46, 22.93)
W/Hr	0.39 (0.03, 4.74)	0.33 (0.02, 6.19)	1.17 (0.09, 15.46)
Selection bias (quartile of birth)	1.43 (0.38, 5.44)	1.48 (0.26, 8.5)	0.96 (0.16, 5.8)
Selection bias (maturation offset velocity)	6 (0.6, 60.44)	3 (0.16, 55.72)	2 (0.18, 22.06)

Pre-PHV pre-peak height velocity, Circa-PHV circa-peak height velocity, Post-PHV post-peak height velocity, WC waist circumference, BMI body mass index, W/Hr waist-to-height ratio

Table 4 Delta with previously published data

	Pre-PHV ($n = +4$)	Circa-PHV ($n = -7$)	Post-PHV ($n = +3$)
	Δ	Δ	Δ
YPHV (years)	− 0.04	+ 0.62	+ 0.91*
Age (years)	− 0.12	+ 0.41	+ 1.28*
Height (cm)	+ 1.50	− 2.19	+ 2.76
Weight (kg)	+ 0.69	− 4.3	+ 2.97
Sitting height (cm)	+ 0.15	+ 1.15	+ 1.1
SH/Hr	− 0.01*	–	–
WC (cm)	− 0.33	− 1.80	+ 2.09*
W/Hr	− 0.02*	–	+ 0.01
PAH (cm)	+ 0.91	+ 2.79	+ 0.03
%PAH (%)	+ 0.35	− 0.49	+ 1.44*
BMI (kg/m^2)	− 0.18	− 1.89	+ 0.28
FM (kg)	+ 0.19	− 0.98	+ 0.37
%FM (%)	+ 0.09	+ 0.37	+ 1.01
FMI	− 0.01	− 0.23	− 0.20
FFMI	+ 0.16	− 0.65	+ 0.48

Data are expressed as mean ± standard deviation

Pre-PHV pre-peak height velocity, Circa-PHV circa-peak height velocity, Post-PHV post-peak height velocity, YPHV years from peak height velocity, SH/Hr sitting height to height ratio, WC waist circumference, PAH predicted adult height, %PAH percentage of predicted adult height, BMI body mass index, FM fat mass, %FM percentage of fat mass, FMI fat mass index, FFMI free fat mass index, W/Hr waist-to-height ratio

*Indicates a p value lower than 0.05

the fittest players, resulting in leaner individuals in the older categories. Despite the conditions to run the χ^2 test were not met, it can be observed that the older players, especially the post-PHV subgroup, show higher probabilities of selection bias based on the relative age effect and, even more, on the maturity offset velocity (Fig. 1 and Table 3). Considering that maturation favorably affects body composition in males [23], it is probable that this aspect determined a selection of the more mature and fittest players. Indeed, in the present study a negative, very strong and a negative, moderate correlation were found between YPHV vs. %FM and FMI, respectively.

The COVID-19 pandemic had an exceptional impact worldwide, affecting almost every aspect of community and individual lives, and physical activity levels dramatically decreased. For this reason, national and international organizations and the scientific and sports communities provided various recommendations to maintain the general population and athletes physically active [24, 25]. Following the COVID-19 pandemic outbreak, the decrease of physical activity levels affected children's physiological and psychological well-being, determining an alarming increase in childhood obesity [26]. Lower physical activity levels may determine negative consequences on body composition, and several aspects can modulate this association [27, 28]. For instance, increased screen time and frequency of snacking between meals negatively affected body composition in children and students [29, 30]. The athletes' population suffered particularly from the impact of restriction measures [4, 31, 32]. In particular, youth male soccer players subjected to COVID-19 lockdown limitations significantly increased FM, due to the impact of the prolonged absence of organized training [12, 13].

Considering that team sports goalkeepers have higher FM than movement players [33], the impact of COVID-19 restrictions can be even worse for those players in this positional role. Still, we found an increase in the number of pre-PHV goalkeepers with abdominal obesity, compared to the previous study [8]. Pre-PHV goalkeepers were already identified as those at higher risk [8]. External factors, such as the COVID-19 pandemic restrictions, may impact them more than their circa- and post-PHV counterparts. This result suggests putting particular attention to those athletes at higher obesity and cardiometabolic risk, like those in less dynamic playing positions and pre-pubescent and pubescent players.

A limitation of the present study is the cross-sectional design which does not allow for defining a causal link between the COVID-19 outbreak and changes in body composition. Furthermore, the sample size was small, especially for three categories (pre-, circa-, and post-PHV). Since the category of appurtenance was defined only after the anthropometric assessment, it was impossible to establish the number of individuals for each subgroup in advance. For this reason, circa-PHV goalkeepers comprised only seven goalkeepers. On the other hand, a strength of the current study is to consider only goalkeepers. Indeed, it is not easy in the literature to find a similar sample. In general, goalkeepers are part of a soccer team (about two), including them together with movement players. Another limitation was that free-living daily physical activity measures were not available despite the hypothesized relevance for body composition. Finally, maturation and body composition were assessed through the anthropometric method, which allows only estimating the variables of interest. However, a trained level III ISAK kinanthropometrist performed the measurements to limit errors. On the other hand, the sample in the current study was very similar to a previously investigated sample, with the only exception of the number of individuals in the subgroups [8]. However, as previously stated, this aspect can only be evaluated after the anthropometric examination and, for this reason, was not predictable.

Conclusions

In conclusion, the young soccer goalkeepers of the present study weakly differed in terms of body composition relating to a comparable sample screened before the COVID-19 pandemic outbreak [8]. Similarly, pre- and circa-PHV goalkeepers showed higher adiposity than their post-PHV counterparts. Despite sports participation, the relatively high number of individuals at risk highlights the importance of monitoring body composition and growth in young athletes. The exceptional circumstances determined by the COVID-19 pandemic outbreak evidenced the need for a holistic approach to the athletes' monitoring that considers not only training routines but also daily life activities and their load [34]. Monitoring body composition, especially close to the growth spurt, can help identify intervention areas related to training and lifestyle.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by SS, PI, GG and AdC. Data curation and formal analysis were performed by SS, PI, RP and GM. The first draft of the manuscript was written by SS and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability The data presented in this study are available from the corresponding author upon request.

Declarations

Conflict of interest The authors have no conflicts of interest relevant to this article.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent All participant provided informed consent prior to their participation.

References

1. Abate Daga F, Agostino S, Peretti S, Beratto L (2021) COVID-19 nationwide lockdown and physical activity profiles among North-western Italian population using the International Physical Activity Questionnaire (IPAQ). Sport Sci Health 17:459–464. https://doi.org/10.1007/s11332-021-00745-8
2. Gjaka M, Feka K, Bianco A et al (2021) The effect of COVID-19 lockdown measures on physical activity levels and sedentary behaviour in a relatively young population living in Kosovo. JCM 10:763. https://doi.org/10.3390/jcm10040763
3. Pišot S, Šimunič B, Gentile A et al (2022) The differences of Slovenian and Italian daily practices experienced in the first wave of covid-19 pandemic. BMC Public Health 22:326. https://doi.org/10.1186/s12889-022-12664-5
4. Izzicupo P, Di Baldassarre A, Abelkalns I et al (2021) Dual careers of athletes during COVID-19 lockdown. Front Psychol 12:657671. https://doi.org/10.3389/fpsyg.2021.657671
5. Roggio F, Trovato B, Ravalli S et al (2021) One year of COVID-19 pandemic in Italy: effect of sedentary behavior on physical activity levels and musculoskeletal pain among university students. IJERPH 18:8680. https://doi.org/10.3390/ijerph18168680
6. Ala-Kitula A, Peltonen J, Finni T, Linnamo V (2019) Physical activity on days with and without soccer practice in 12–13-year-old boys. Sci Med Football 3:245–250. https://doi.org/10.1080/24733938.2018.1562276
7. Telford RM, Telford RD, Cochrane T et al (2016) The influence of sport club participation on physical activity, fitness and body fat during childhood and adolescence: the LOOK longitudinal study. J Sci Med Sport 19:400–406. https://doi.org/10.1016/j.jsams.2015.04.008
8. Di Credico A, Gaggi G, Ghinassi B et al (2020) The influence of maturity status on anthropometric profile and body composition of youth goalkeepers. Int J Environ Res Public Health. https://doi.org/10.3390/ijerph17218247
9. Gil SM, Gil J, Ruiz F et al (2007) Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. J Strength Cond Res 21(2):438–445. https://doi.org/10.1519/r-19995.1
10. Lago-Peñas C, Casais L, Dellal A et al (2011) Anthropometric and physiological characteristics of young soccer players according to their playing positions: relevance for competition success. J Strength Cond Res 25:3358–3367. https://doi.org/10.1519/JSC.0b013e318216305d
11. Rebelo-Gonçalves R, Coelho-e-Silva MJ, Severino V et al (2015) Anthropometric and physiological profiling of youth soccer goalkeepers. Int J Sports Physiol Perform 10:224–231. https://doi.org/10.1123/ijspp.2014-0181
12. Alvurdu S, Baykal C, Akyildiz Z et al (2022) Impact of prolonged absence of organized training on body composition, neuromuscular performance, and aerobic capacity: a study in youth male soccer players exposed to COVID-19 lockdown. IJERPH 19:1148. https://doi.org/10.3390/ijerph19031148
13. Korkmaz S, Aslan CS, Eyuboğlu E et al (2020) IImpact of detraining process experienced during the COVID-19 pandemic on the selected physical and motor features of football players. Progress Nutr 22:e2020029. https://doi.org/10.23751/pn.v22i2-S.10605
14. Winter EM, Maughan RJ (2009) Requirements for ethics approvals. J Sports Sci 27:985–985. https://doi.org/10.1080/02640410903178344
15. Brambilla P, Bedogni G, Heo M, Pietrobelli A (2013) Waist circumference-to-height ratio predicts adiposity better than body mass index in children and adolescents. Int J Obes 37:943–946. https://doi.org/10.1038/ijo.2013.32
16. Cacciari E, Milani S, Balsamo A et al (2002) Italian cross-sectional growth charts for height, weight and BMI (6–20 y). Eur J Clin Nutr 56:171–180. https://doi.org/10.1038/sj.ejcn.1601314
17. McCarthy H, Jarrett K, Crawley H (2001) The development of waist circumference percentiles in British children aged 5.0–16.9

y. Eur J Clin Nutr 55:902–907. https://doi.org/10.1038/sj.ejcn.1601240
18. Maffeis C, Banzato C, Talamini G, Obesity Study Group of the Italian Society of Pediatric Endocrinology and Diabetology (2008) Waist-to-height ratio, a useful index to identify high metabolic risk in overweight children. J Pediatr 152:207–213. https://doi.org/10.1016/j.jpeds.2007.09.021
19. Mirwald RL, Baxter-Jones ADG, Bailey DA, Beunen GP (2002) An assessment of maturity from anthropometric measurements. Med Sci Sports Exerc 34:689–694. https://doi.org/10.1097/00005768-200204000-00020
20. Sherar LB, Mirwald RL, Baxter-Jones ADG, Thomis M (2005) Prediction of adult height using maturity-based cumulative height velocity curves. J Pediatr 147:508–514. https://doi.org/10.1016/j.jpeds.2005.04.041
21. Brustio PR, Lupo C, Ungureanu AN et al (2018) The relative age effect is larger in Italian soccer top-level youth categories and smaller in Serie A. PLoS One 13:e0196253. https://doi.org/10.1371/journal.pone.0196253
22. Schober P, Boer C, Schwarte LA (2018) Correlation coefficients: appropriate use and interpretation. Anesth Analg 126:1763–1768. https://doi.org/10.1213/ANE.0000000000002864
23. Loomba-Albrecht LA, Styne DM (2009) Effect of puberty on body composition: current opinion in endocrinology. Diabetes Obes 16:10–15. https://doi.org/10.1097/MED.0b013e328320d54c
24. Ricci F, Izzicupo P, Moscucci F et al (2020) Recommendations for physical inactivity and sedentary behavior during the coronavirus disease (COVID-19) pandemic. Front Public Health 8:199. https://doi.org/10.3389/fpubh.2020.00199
25. Lim MA, Pranata R (2021) Sports activities during any pandemic lockdown. Irish J Med Sci (1971-) 190:447–451. https://doi.org/10.1007/s11845-020-02300-9
26. Kim ES, Kwon Y, Choe YH, Kim MJ (2021) COVID-19-related school closing aggravate obesity and glucose intolerance in pediatric patients with obesity. Sci Rep 11:5494. https://doi.org/10.1038/s41598-021-84766-w
27. Condello G, Capranica L, Stager J et al (2016) Physical activity and health perception in aging: do body mass and satisfaction matter? A three-path mediated link. PLoS One 11:e0160805. https://doi.org/10.1371/journal.pone.0160805
28. Izzicupo P, Di Blasio A, Di Credico A et al (2021) Objectively measured physical activity increases only in males during a summer camp for obese children. Front Sports Act Living 3:624449–8. https://doi.org/10.3389/fspor.2021.624449
29. Pietrobelli A, Pecoraro L, Ferruzzi A et al (2020) Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in Verona, Italy: a longitudinal study. Obesity 28:1382–1385. https://doi.org/10.1002/oby.22861
30. Chwałczyńska A, Andrzejewski W (2021) Changes in body mass and composition of the body as well as physical activity and time spent in front of the monitor by students of the Wroclaw University of Health and Sport Sciences during the period of COVID-19 restrictions. IJERPH 18:7801. https://doi.org/10.3390/ijerph18157801
31. Ambroży T, Rydzik Ł, Obmiński Z et al (2021) The impact of reduced training activity of elite kickboxers on physical fitness, body build, and performance during competitions. Int J Environ Res Public Health 18:4342. https://doi.org/10.3390/ijerph18084342
32. Parpa K, Michaelides M (2021) The impact of COVID-19 lockdown on professional soccer players' body composition and physical fitness. Biol Sport 38:733–740. https://doi.org/10.5114/biolsport.2021.109452
33. Di Credico A, Gaggi G, Vamvakis A et al (2021) Bioelectrical Impedance vector analysis of young elite team handball players. IJERPH 18:12972. https://doi.org/10.3390/ijerph182412972
34. Izzicupo P, Di Baldassarre A, Ghinassi B et al (2019) Can off-training physical behaviors influence recovery in athletes? A Scoping Review Front Physiol 10:448. https://doi.org/10.3389/fphys.2019.00448