ORIGINAL ARTICLE

Prospective analysis of physical activity levels and associated fitness factors amid COVID-19 pandemic and social-distancing rules. A special focus on adolescents

Analyse prospective des niveaux d'activité physique et des facteurs de forme physique associés au milieu des règles de pandémie et de distance sociale COVID-19. Un accent particulier sur les adolescents

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Summary
Objective. — Physical activity is a significant health determinant and is likely to be influenced by social-distancing rules imposed by authorities during the COVID-19 pandemic. This study explored gender-based differences in physical activity levels (PALs) and associated factors amid COVID-19 pandemic in adolescents.
Methods. — In this prospective analysis, 112 healthy adolescents (15.63 ± 1.21 years) participated. They were assessed at the baseline (before the announcement of COVID-19 as a global pandemic) for anthropometry, fitness status, and PALs (baseline-PALs), and next at the follow-up (three months of imposed social-distancing rules) for PALs (follow-up-PALs) over an internet-based platform through the Physical Activity Questionnaire for Adolescents.

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Results. — A significant PALs decline was evidenced for the whole sample (*P* < .001) and such a decline was predominantly affected by significant PALs reduction among males (*P* < .001) rather than in females (*P* = .06). The fitness variables (explosive power, muscle endurance, flexibility, and aerobic endurance) were consistently positively correlated with the baseline- and follow-up-PALs in both genders with particularly prominent associations of PALs with explosive power and aerobic endurance.

Conclusion. — Physical literacy is necessary for PALs preservation, given the remarkable PALs decreases among adolescents during challenging circumstances such as the COVID-19 pandemic.

Résumé
Objectif. — L'activité physique est un déterminant important de la santé et est susceptible d'être influencée par les règles de distanciation sociale imposées par les autorités pendant la pandémie de COVID-19. Cette étude a exploré les différences basées sur le sexe dans les niveaux d'activité physique (PAL) et les facteurs associés au milieu de la pandémie de COVID-19 chez les adolescents.

Méthodes. — Dans cette analyse prospective, 112 adolescents en bonne santé (15,63 ± 1,21 ans) ont participé. Ils ont été évalués au départ (avant l'annonce du COVID-19 en tant que pandémie mondiale) pour l'anthropométrie, le statut de forme physique et les PAL (PAL de référence), et ensuite lors du suivi (trois mois de règles de distanciation sociale imposées) pour les PAL (suivi-PAL) sur une plate-forme internet via le questionnaire sur l'activité physique pour adolescents.

Résultats. — Une baisse significative des PAL a été mise en évidence pour l'ensemble de l'échantillon (*p* < ,001) et une telle baisse a été principalement affectée par une réduction significative des PAL chez les hommes (*p* < ,001) plutôt que chez les femmes (*p* = ,06). Les variables de forme physique (puissance explosive, endurance musculaire, flexibilité et endurance aérobie) étaient constamment corrélées positivement avec les PAL de référence et de suivi chez les deux sexes avec des associations particulièrement importantes de PAL avec la puissance explosive et l'endurance aérobie.

Conclusion. — La littératie physique est nécessaire pour la préservation des PAL, étant donné les diminutions remarquables des PAL chez les adolescents lors de circonstances difficiles telles que la pandémie de COVID-19.

1. Introduction

Evidence exists from both experimental and observational studies that adolescents' participation in physical activity (PA) offers benefits for the physical and psychological well-being. Up-to-date epidemiological studies have shown further meaningful correlations than had been previously identified and helped explaining dose-response relationships between PA and health outcomes [1,2]. The recently issued PA guidelines recommend that adolescents should engage in at least an hour a day in moderate-to-vigorous PA [3]. Even so, it has been noted that the vast majority of adolescents do not reach the bare minimum of PA [4]. Since childhood and adolescence are the most critical stages for the development of health-related behaviors and promotion of PA [5], achieving a reasonable PA levels (PALs) in such a period is vitally important, especially that inactive lifestyle can increase the risk of adverse cardiac, metabolic, and mental health conditions [6—9].

Until recently, the issue of the decline in PALs, particularly among adolescents in Saudi Arabia and nearby regions, had not been thoroughly investigated. Negative trends in motor competencies have, however, been occasionally demonstrated, although recent studies have demonstrated global negative trends of worrying declines in PALs [10,11]. Alqahtani et al. described the PA pattern in various age groups of Saudis and evidenced a considerable reduction in the PALs among adolescents aging 15—19 years, and girls were less active than boys [10]. Al-Nuaim et al. explored the lifestyle and the gender-based differences concerning PALs in adolescents. They indicated that about 58.6% of the total sample were inactive and 17.15% were minimally-active, and the PAL influenced by the gender [11].

The current outbreak of the coronavirus disease 2019 (COVID-19) causes global health-concerns. COVID-19 has affected a large population of the world, with almost 34,495,176 confirmed cases, including 1,025,729 deaths (as of October 4th, 2020), and there exist virtually no area that has not been affected by this danger [12]. Even though most people with COVID-19 suffer from uncomplicated mild-to-moderate respiratory illnesses and recover with no specific treatments, approximately 14% are more likely to develop severe illnesses, including elderly and persons who experience chronic respiratory/cardiovascular disorders, diabetes mellitus, or malignancy [13]. The current evidence has shown that COVID-19 viruses are mainly transmitted through respiratory droplets and contact pathways between people, and therefore, the social-distancing was the most feasible measure, recommended by the World Health Organization,

and imposed thereafter by authorities, to control this pandemic [14].

Although COVID-19 itself has adverse effects on health, the social-distancing also has a negative impact on PALs. Chen et al. identified a rise in sedentary behaviors because of the pandemic and resulting home-staying policies, right after the outbreak of the disease [15]. After that, a few studies shed light on the problem of PA in such circumstances, how important it is for public health and well-being, and proposed home exercises-paradigms that people can perform during COVID-19 pandemic and social-distancing [16—18]. More recently, several reports from different countries indicated that the COVID-19 mitigation strategies have impacted PA. One study on 1491 adults from Australia reported negative changes in PA during the pandemic and that these changes were associated with various psychological factors [19]. Similarly, findings from another survey including 399 participants from the United Kingdom's citizens or long-term residents demonstrated that PA, among various health behaviors, has been reduced during pandemic-associated restrictions and that being physically inactive was associated with a more negative mood [20]. Additional analysis of the PA behavior of 2042 Spanish population before and during the pandemic revealed that the PA behavior changed during the pandemic such that 51.1% of the cohort did not meet the recommended World Health Organization (WHO) PA levels [21]. A few reports from studies in the Middle East region have also pointed out the negative impacts on PA quarantine in the context of COVID-19 pandemic [22,23]. Despite the importance of these studies, they have been limited by merging data from different age groups and none of them have explored the relationship of PA with the prior fitness status.

Building on this prior evidence, this study sought to examine PALs changes caused by the COVID-19 epidemic and social distancing policies among adolescents, and to define physical fitness factors linked to the PALs and PALs shifts in such age-group. We assumed that, because of pandemic and social-distancing policies, adolescents' PALs will decrease substantially and that an association of PALs with fitness variables could exist.

2. Methods

2.1. Design and subjects

This study included 112 adolescents from Al-Kharj governorate, Saudi Arabia. Subjects were attending to their schools and most of them were urban residential. They were healthy adolescents (which implies that adolescents engaged in regular PA sessions twice/week, with some engaging in non-competitive extracurricular sports activities), and their age was 14—18 years. This research commenced as a part of a previously planned project (Effect of physical activity on serum 25-hydroxy vitamin D3 among Saudi adolescents). Consequently, all subjects previously had knowledge about research goals, risks, and benefits. The protocol for the original investigation approved by the Institutional Research-Ethics Committee (No: RHPT/0019/0061), and parental consent form was attained.

Subjects were assessed on two circumstances: at the baseline (before social-distancing imposition), and next at the follow-up (through social-distancing, three months since it has been imposed). The baseline assessment included anthropometry, fitness status, and baseline-PALs—(details are described below). For this study, it is worth noting that during this period, no changes were made to the school schedule due to the COVID-19 pandemic in Saudi Arabia. In addition, no sports or social restrictions have been imposed, while individuals with a confirmed diagnosis of COVID-19 infection were quarantined and/or admitted to the hospital or placed in a self-isolation. The follow-up assessment involved the PALs examination (follow-up-PALs). Over that time, several measures have already been implemented for controlling the COVID-19 pandemic. In March 2020, schools were closed, many stringent steps to discourage public meetings and the closing down of cafes, shopping malls, fitness and sports centers, and worship places, were enforced by the Government. The municipality was also entitled, as it had been in the area where we recruited the sample, to close recreational and open-play areas. In the meantime, various types of solitary practice (such as walking, running, and biking) were not strictly prohibited.

2.2. Measurements

2.2.1. Physical activity level

The baseline- and follow-up-PALs measured using the Arabic version of Adolescents Physical Activity Questionnaire (PAQ-A). The data gathered via an online podium. This PAQ-A has been proved as a valid measure of PALs in adolescents from Arab countries [24]. It includes 9 items that assess the PALs in the past 7 days within various contexts (e.g., sports activity, physical education, free play after school, in the evening, at weekends, and active-transportation). Each item rated on a 5-point scale (1 indicates low PALs and 5 delineates high PALs) except item 9, which was not used as part of the summary activity score, but rather used to identify subjects who had unusual PAL during the previous week (i.e., give evidence of injury/illness suffering that helped know whether the participant's data was valid). The total PALs computed as the mean of the 8 items' scores. To identify the magnitude of the change in PALs caused by the COVID-19 pandemic and social-distancing, we calculated the difference between baseline- and follow-up-PALs and reported as △PALs [25].

2.2.2. Physical fitness

The physical fitness indicated through four tests; all were part of the fitness monitoring program in the participants' schools and were administered by an experienced examiner—pediatric physical therapist as follows:

- Broad-jump test: employed to measure explosive power. A two-foot take-off and landing were used. Subjects were instructed to stand feet together behind a marked, take-off line on a broad-jump landing mat, bent their knees, swing their arms to provide forward drive, and jump as far as possible, landing on both feet. Three attempts within 20 seconds were permitted and the average distance (in *cm*) covered during the three attempts was documented;

Table 1 Anthropometric characteristics and baseline fitness status for the whole sample and gender-stratified.

Variable	Whole sample (n = 112)	Males (n = 64)	Females (n = 48)	M/F difference (P-value)
Anthropometrics				
Age, year	15.63 ± 1.21	15.78 ± 1.31	15.41 ± 1.03	.12
Weight, Kg	57.58 ± 6.96	56.16 ± 7.23	59.48 ± 6.16	.012
Height, m	1.62 ± 0.08	1.61 ± 0.08	1.63 ± 0.07	.17
BMI, Kg/m^2	21.84 ± 1.69	21.43 ± 1.46	22.38 ± 1.84	.003
Fitness status				
Broad-jumping, cm	127.94 ± 24.75	138.89 ± 22.32	113.33 ± 19.95	< .001
Sitting-ups, repetition	19.78 ± 4.17	20.97 ± 4	18.19 ± 3.89	.0004
Sit-and-reach, cm	30.02 ± 2.76	28.81 ± 2.37	31.63 ± 2.41	< .001
Multi-level fitness, level	14.79 ± 2.43	15.16 ± 2.45	14.29 ± 2.33	.062

Data are listed as mean ± SD; BMI: body mass index; M/F diff: difference among males and females.

- Sit-up test: applied to evaluate abdominal and hip flexor muscles' endurance. While subjects lying on the exercise mat, knees bent at a right angle, and fingers interlocked behind the head, and the examiner holding feet down on the floor, subjects were asked to raise the chest until the upper body becomes vertical, then return to the floor. Subjects were instructed to perform as many sit-ups as possible over 30 seconds. The maximal possible number of correctly executed sit-ups from a single attempt was reported;
- Sit-and-reach test: utilized to assess flexibility. While subjects in a sitting position with their legs outstretched, feet flattened against a standard measuring box, and knees held down, they were asked to reach forward as far as possible along the measuring line with their hands either side-by-side or on the top of each other, palms facing down, and were asked to hold for 1—2 seconds to record the distance (in cm). Three attempts were allowed and were averaged;
- Multi-level fitness test: used to quantify the sub-maximal aerobic endurance [26]. The test involved continues running back-and-forth between two cones, 20-meters apart. The runs coincided with audio recordings that played beeps on predetermined intervals. With progression, beep-intervals were decreased, pushing subjects to run faster till becoming difficult to conform with the recording. The test was organized in 21 levels, each lasted approximately 62 seconds. Beep-intervals measured as requesting a start-speed of 8.5 km/h, rising 0.5 km/h for each next stage. The stage-to-stage progression indicated with triple short beeps. Prior to struggling to keep, the highest achieved level was registered.

2.3. Data analysis

Skewness and kurtosis of all data were computed using D'Agostino—Pearson omnibus test. The baseline-to-follow-up PALs changes and gender-specific differences were analyzed using the two-way repeated measure Anova, with a post-hoc t-test. The PALs associations with anthropometric and fitness variables were measured by Pearson's correlation coefficient. The major determinants of PALs among anthropometric and fitness variables were identified through the stepwise linear-regression, using the forward selection procedure. All analyses were conducted via the Minitab statistical software, version 19.2 (Minitab Inc., State College PA, USA), with the significance level accepted at P value of < .05.

3. Results

The baseline anthropometric and fitness characteristics and gender-differences are outlined in Table 1. Age and height were similar in male and female adolescents whereas the bodyweight and BMI were significantly different among both genders. In most fitness variables, males achieved substantially better than girls except for sit-and-reach. No significant between-gender difference was detected regarding the multi-level fitness.

The two-way repeated measure Anova demonstrated a significant large effect of the time from baseline to follow up on PAL (P < .001) and a significant medium time-by-gender interaction (P < .001). The post-hoc t-test indicated a significant reduction in PALs for the entire sample (baseline-PALs = 3.04 ± 0.56, follow-up-PALs = 2.74 ± 0.46, △PALs = 0.27 ± 0.36, and P < .001). When the sample was gender-stratified, a significant PALs reduction was observed in male adolescents (baseline-PALs = 3.22 ± 0.57, follow-up-PALs = 2.79 ± 0.49, △PALs = 0.43 ± 0.38, and P < .001) whereas a non-significant PALs reduction was found in female adolescents (baseline-PALs = 2.80 ± 0.45, follow-up-PALs = 2.73 ± 0.48, △PALs = 0.06 ± 0.23, and P = .06) (Fig. 1). There was also a significant gender-difference in the baseline-PALs (P < .001), where male adolescents displayed higher PALs. Nevertheless, male and females showed similar PALs at the follow-up occasion (P = .50).

Correlation analyses are summarized in Table 2. For the entire sample, the baseline- and follow-up-PALs were negatively associated with bodyweight and BMI and were positively associated with all fitness measures. When data were split by gender, the baseline- and follow-up-PALs were negatively associated with bodyweight and BMI in male adolescents, and positively with all fitness measures, among both male and female adolescents. The △PALs was positively associated with broad-jump, set-up, and multilevel fitness in the whole sample. The △PALs was positively asso-
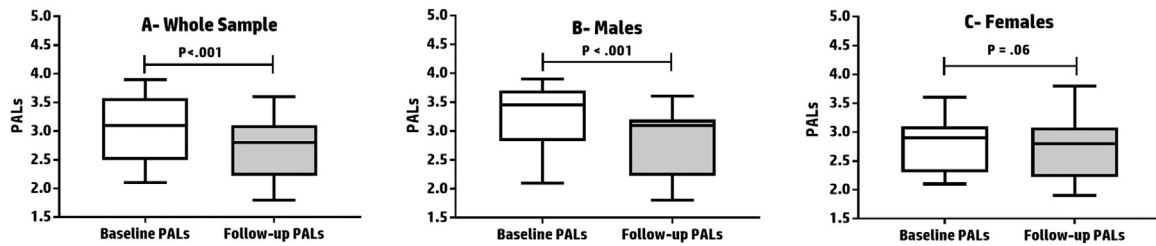
Figure 1 Physical activity levels for whole sample and gender-stratified at the baseline and follow-up occasions.

Table 2 Relationship between PALs, and anthropometric and fitness variables among males ($n = 64$), females ($n = 48$), and whole sample ($n = 112$).

Variables	Baseline-PALs (r)			Follow-up-PALs (r)			$\triangle$PALs (r)		
	M	F	Whole	M	F	Whole	M	F	Whole
Weight	−0.27*	0.12	−0.21*	−0.35*	0.15	−0.22*	0.08	0.19	−0.03
Height	−0.14	0.03	−0.11	−0.17	−0.07	−0.14	0.02	0.20	−0.02
BMI	−0.28*	0.13	−0.20*	−0.40*	0.11	−0.18*	0.09	0.02	−0.09
Broad-jump	0.65**	0.70**	0.72**	0.49**	0.60**	0.49**	0.36*	0.11	0.46**
Sit-ups	0.63**	0.53**	0.64**	0.44**	0.49**	0.46**	0.40*	−0.04	0.38**
Sit-and-reach	0.70**	0.57**	0.32*	0.43**	0.37*	0.44*	0.49**	0.19	0.04
Multi-level fitness	0.74**	0.63**	0.69**	0.54**	0.43**	0.54**	0.43**	0.12	0.36**

M: male; F: females; BMI: body mass index; r: Pearson's correlation coefficient
* $P < .05$
** $P < .001$

ciated with all fitness variables in male adolescents but not in female adolescents.

The stepwise regression analysis outcomes are presented in Table 3. For the whole sample, all fitness variables predicted the baseline-PALs (explained 73% of PALs difference) and follow-up-PALs (accounted for 78% of difference), while broad-jump was the sole predictors of $\triangle$PALs (contributed to 21% of difference). For male adolescents, all fitness variables predicted baseline-PALs (explained 87% of PALs variance). Also, the BMI (accounted for 9% of variance) and some fitness variable, which are the sit-ups and multilevel fitness (explained 44% of variance) predicted the follow-up-PALs. Further, sit-and-reach was the single predictor of the $\triangle$PALs (explained 25% of variance). For female adolescents, the broad jump and multi-level fitness together elucidated 57% and 42% of the baseline- and follow-up-PALs, respectively, whereas none of the fitness variables predicted the $\triangle$PALs.

4. Discussion

The PALs reduced among male adolescents than was the case before the COVID-19 pandemic and social-distancing, while the decrease in PAL among girls was not remarkable. Significant associations of the baseline- and follow-up-PALs with anthropometric and fitness variables were noticed. More explicitly, the bodyweight and BMI were significant correlates with PALs in males, while the fitness variables (i.e., explosive power, muscle endurance, flexibility, and aerobic endurance) were significant correlates to PALs in both genders. Further, fitness measures were significantly correlated with $\triangle$PALs among male adolescents only.

Adolescents, in general, decreased PALs and these changes seemed, however, to be gender-related. Whilst changes in PALs among males and females sound disputable, two specific considerations may elucidate them; the baseline-PALs disparities and the type of PA being examined. For males, the baseline-PALs were considerably greater than that of females. This has been borne out by earlier surveys in Saudi Arabia [10,11], neighboring countries [27], and other regions across the world, where researchers consistently reported higher PALs in males than in females of matched-age [28]. Owing to these disparities, the social-distancing caused PALs to decrease more clearly in males than in females. In addition, the nature of PA varies between them. Very briefly, previous studies showed that males engage in competitive sport more frequently than females [10,29]. Sports activity in all facilities were banned when follow-up-PALs was assessed, so it makes sense for males to have more decline in PALs. The findings of the present study come in agreement with several recently published reports from different countries, which demonstrated that the COVID-19 pandemic and related mitigation strategies led to a reduction in PALs among population of different age groups including adolescents [18–23].

The bodyweight and BMI were significantly linked to baseline- and follow-up-PALs in males, however, these links were generally negligible for females as well as for the entire sample. The baseline fitness, conversely, was meaningfully correlated with baseline-PALs for the two genders, where adolescents with increased baseline-PALs were more fit. Such findings can be seen likely, because investigations have consistently established these associations between adolescents [30]. Regardless of discrepancies in associations

Table 3 Details of the stepwise regression outcomes.

Independent variables	Males (n = 64)			Females (n = 48)			Whole sample (n = 112)		
	β	R²	P-value	β	R²	P-value	β	R²	P- value
Baseline-PALs									
Broad-jump	0.23	0.54	< .001	0.51	0.49	< .001	0.37	0.52	< .001
Sit-ups	0.25	0.15	< .001	—	—	—	0.25	0.05	< .001
Sit-and reach	0.24	0.05	.001	—	—	—	0.12	0.02	.037
Multi-level fitness	0.41	0.03	.004	0.35	0.08	.005	0.35	0.14	< .001
Follow-up-PALs									
BMI	−0.30	0.09	.016	—	—	—	—	—	—
Broad-jump	—	—	—	0.44	0.36	< .001	0.23	0.24	.02
Sit-ups	0.26	0.06	.003	—	—	—	0.17	0.03	.001
Sit-and-reach	—	—	—	—	—	—	0.19	0.02	.04
Multi-level fitness	0.39	0.29	< .001	0.28	0.06	.04	0.28	0.29	< .001
△PALs									
Broad-jump	—	—	—	—	—	—	0.46	0.21	< .001
Sit-and-reach	0.49	0.25	< .001	—	—	—	—	—	—

PALs: physical activity levels; BMI: body mass index; β: standardized regression coefficient; R²: refers to the change in the explained variance when the corresponding variable added in the regression model.

between males and females, it is not currently possible to define whether fitness status is an impact factor on baseline-PALs or whether the cause-and-effect relationships should be explained in the reverse direction. Of course, the physically-fit adolescents may have improved their fitness-capacities more than their less-active counterparts. It is also comprehensible, besides, that the more-fit adolescents would not suffer in heavy physical effort and thus show greater baseline-PALs.

The follow-up-PALs was associated with baseline fitness in both genders. However, the △PALs were associated with fitness variables in male adolescents only. It possibly points out that, even during the enforced social-distancing that precluded males and females with enhanced-fitness from becoming active like always, they tended to have a higher PALs. To interpret these results, various common aspects of PA epidemiology and related factors may be useful in understanding them. Research has already assessed factors that had favorable or unfavorable influence on PALs. The key factors, which are particularly important for participating adolescents and the evaluation time (i.e., COVID-19 pandemic) include health perception, intention and enjoyment of exercise, preconceptions about exercise benefits, self-efficacy, self-motivation, and social support [31]. Though in this analysis, these factors were not directly evaluated, it is commonly recognized and hence predicted that most of the characteristics listed earlier have essentially existed in adolescents who were fitter at the baseline, especially since it is not possible to maintain a good fitness without engagement in consistent activities such as PA programs. Supportive of this, preceding reports that pointed out that adolescents participating in physically-demanding activities are positively affected in many respects, as they believe more in their capabilities, their hormonal responses are preferable, their awareness of the importance of PA and expectations of its benefits are greater [32,33]. Thus, even when circumstances did not allow to be active, adolescents who have these peculiarities are more likely to engage in some kind

of PA. Also, parental support is well-known as being a determining factor for adolescents' PALs [34]. Therefore, it might be anticipated that more physically-fit adolescents may have obtained appropriate social reinforcement to maintain an active-lifestyle, which led to baseline-PALs elevation and improved fitness. Parental influence might have also been increased during the period of follow-up-PALs measurement, simply because they probably staying at home longer alongside their family. The factors mentioned earlier to define the fitness impacts on follow-up-PALs maybe conceived via the "physical literacy" concept [35], which may, specifically, be defined as, the drivers for participation in PA such as awareness of PA benefits, self-motivation, confidence, and physical competency. It has been pointed out that physical literacy is imperative for the acquisition of fundamental life-skills by all adolescents, enabling them to face challenges in life [36]. In our view, the foregoing quote sums up various facets of physical literacy that in present challenging times have resulted jointly in the relationship between fitness status and PALs. Adolescents with higher physical-literacy levels, in fact, may have been able to apply their experience, whether theoretical and practical, even if they were unable to exercise regularly. Also, Adolescents with higher physical-literacy levels may have undoubtedly understood how much PA is necessary, were properly encouraged, and were adequately qualified to select and apply other forms of PA, even though circumstances have changed dramatically amid the current COVID-19 pandemic.

Despite the value of this study, the authors are still aware of some limitations that may affect the interpretation of its findings. The usage of a self-reported measure for the key variable (i.e., PALs), which can subject to recall- and social-desirability biases and may trigger PA over-reports. However, this limitation has no major impact on our results, as a comparable bias for the baseline- and follow-up-PALs measures can be expected. Also, fitness status has been measured using field-tests which are less reliable compared to the laboratory tests. Eventually, the sample was

relatively small, while examining larger samples representative of wider areas would help to draw meaningful conclusions.

5. Conclusion

Our findings demonstrated that during the COVID-19 pandemic, the PALs decreased remarkably among adolescents. PALs changes have primarily been affected by the PALs decline among boys. The baseline- and follow-up-PALs were greatly influenced by the baseline fitness level. When regular PA was compromised because of COVID-19, the baseline fitness level consistently associated with higher PALs.

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Disclosure of interest

The authors declare that they have no competing interest.

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