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Variation in physical fitness and the impact of COVID-19 in young Colombian adults: An 11-year observational retrospective study

Variación de la condición física e impacto de la COVID-19 en adultos jóvenes colombianos: Un estudio retrospectivo observacional de 11 años

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Abstract. Introduction. Low levels of physical activity (PA) have become one of society's major problems. Physical fitness is a predictor of health. Objective. The present study investigates temporary changes in lower limb power, running speed, flexibility and cardiorespiratory fitness before and after COVID-19. Material & Method. Cross-sectional data were collected from 2.942 young people (17-21 years old) of both sexes between 2011 and 2022. Performance was analyzed in relation to the explosive strength of the lower limbs based on standing long jump (SLJ), flexibility (sit-and-reach), cardiorespiratory resistance (20 m Shuttle Run Test) and speed (SP-30 m). Results.The results indicate significant (p<0.001) strong and moderate (ES = 0.45 to 1.45) decreases in the shuttle run in most periods for young people of both sexes, although the decline in women's performance was twice that of men. The SLJ also showed a significant (p<0.001) weak and moderate (ES = 0.07-1.86) decrease in most periods, with a stronger decline in men. The sit-and-reach test did not demonstrate significant differences by either sex or period. In the SP-30 m, significant (p<0.001) weak (ES = 0.12) decreases were observed in the race time for men only between 2011-2022, while there were significant (p<0.001) strong (ES = 1.8-2.0) increases for women in some periods. Conclusions. The silent pandemic of physical inactivity and sedentary behaviors has had a greater effect than COVID-19 on levels of physical inactivity and sedentary behavior. The results of this study indicate a gradual and sustained reduction in the physical fitness of young adults throughout the past decade, which was greater than that caused by confinement due to the COVID-19 pandemic. This indicates that the level of physical fitness is so low that confinement did not generate significant effects on the reduction in physical fitness in the young adult population. In other words, the silent pandemic of physical inactivity and sedentary behaviors has had a greater effect than COVID-19 on levels of physical inactivity and sedentary behaviors.

Keywords: Temporal trends, COVID-19, Physical fitness, Maximal oxygen peak, Stretching.

Resumen. Introducción. Los bajos niveles de actividad física (AF) se han convertido en uno de los principales problemas de la sociedad. La forma física es un factor predictivo de la salud. Objetivo. El presente estudio investiga los cambios temporales en la potencia de las extremidades inferiores, la velocidad de carrera, la flexibilidad y la aptitud cardiorrespiratoria antes y después de COVID-19. Material y método. Se recogieron datos transversales de 2.942 jóvenes (17-21 años) de ambos sexos entre 2011 y 2022. Se analizó el rendimiento en relación a la fuerza explosiva de los miembros inferiores basada en el salto de longitud de pie (SLJ), la flexibilidad (Sit-and-Reach), la resistencia cardiorrespiratoria (20 m Shuttle Run Test) y la velocidad (SP-30 m). Los resultados indican descensos significativos (p<0,001), fuertes y moderados (ES = 0,45 a 1,45), en la carrera de lanzadera en la mayoría de los periodos para los jóvenes de ambos sexos, aunque el descenso en el rendimiento de las mujeres fue el doble que en el de los hombres. El SLJ también mostró una disminución significativa (p<0,001) débil y moderada (ES = 0,07 a 1,86) en la mayoría de los períodos, con una disminución más fuerte en los hombres. La prueba de sentarse y alcanzar no demostró diferencias significativas por sexo o período. En la SP-30 m, se observaron disminuciones significativas (p<0,001) débiles (ES = 0,12) en el tiempo de carrera sólo para los hombres entre 2011-2022, mientras que hubo aumentos significativos (p<0,001) fuertes (ES = 1,8-2,0) para las mujeres en algunos períodos. Conclusiones. La pandemia silenciosa de inactividad física y conductas sedentarias ha tenido un efecto mayor que el COVID-19 en los niveles de inactividad física y conductas sedentarias. Los resultados de este estudio indican una reducción gradual y sostenida de la aptitud física de los adultos jóvenes a lo largo de la última década, que fue mayor que la causada por el confinamiento debido a la pandemia COVID-19. Esto indica que el nivel de aptitud física es tan bajo que el confinamiento no generó efectos significativos en la reducción de la aptitud física en la población de adultos jóvenes. En otras palabras, la pandemia silenciosa de inactividad física y conductas sedentarias ha tenido un efecto mayor que el COVID-19 sobre los niveles de inactividad física y conductas sedentarias.

Palabras clave: Tendencias temporales, COVID-19, Aptitud física, Pico máximo de oxígeno, Estiramientos.

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Introduction

For several decades, a growing decline in the fitness level of the younger generation has been reported as a consequence of sedentary lifestyles (Booth et al., 2012; Park et al., 2020) caused by increasing industrialization. For example, Tomkinson et al. in a large study where they collected data from 1.185.656 Eurofit tests, observed a generalized decline in aerobic capacity in a population of children and young people aged 7-18 years in 23 European countries. In the same vein, several meta-analyses have shown a decrease in cardiorespiratory fitness and a stabilization of muscular strength in recent years (Macfarlane & Tomkinson, 2007; Tomkinson & Olds, 2007; Tomkinson, Olds & Borms, 2007). Similarly, Matton et al. (2007) and Jürimäe et al. (2007) indicated reductions in motor skills (power, muscle strength and speed-agility) in young people from northern European countries. Westerstahl et al. (2003) observed better performance in Swedish 16-year-old boys in 1995 than in 1974 in the

Sargent jumping and flexibility tests.

Tomkison et al. (2021) extracted data from 34 studies of 10.940.801 children and adolescents from 24 high-income countries, 4 upper-middle-income countries, and 1 low-income country between 1960 and 2017 to estimate national and international temporal trends in long jump (SBJ) performance. They observed an insignificant improvement (per decade) in SBJ performance of 1.73 cm (95 % CI: 1.71-1.75), 0.99 % (95 % CI: 0.97-1.01) with a standardized effect size of 0.07 (0.07-0.07) over the entire period, with a steady rate of improvement from the 1960 through the 1980, slowing in the 1990, before declining. The study concludes by indicating a decline from 2000 onwards in explosive strength performance in children and adolescents. These results are contradictory to the study by Pinoniemi et al. (2020) who observed, on the contrary, a small increase in jump length of 12.6 cm in 65,527 young Americans (aged 10 to 17 years) between 1911 and 1990.

In another study by Tomkison et al. (2021) using data from 137 studies, they estimated time trends for 965 264 children and adolescents from 19 high-, middle-, and high-income countries between 1981 and 2014. Overall, they identified a moderate decrease in oxygen consumption of 3.3 mL/kg/min (95% CI -3.5 to -3.1), equivalent to 7.3% (95% CI -7.8% to -6.7%) over the 33-year period. This international decline occurred with each decade and leveled off around 2000. Trends also differed in magnitude and direction among countries, but most showed declines.

Vanhelst et al. (2024) analyzed functional physical capacity data from several cross-sectional studies in 15420 French children and adolescents aged 9 to 16 years between 1999 and 2022. They identified a large decrease in mean 20m round-trip sprint performance (decadal trend (95% CI: -1.42 SD (-1.45, -1.39) or -18.4% (95% CI: -18.8, -18.0)) between 1999 and 2022. and observed a breakpoint in 2010. There was a large decrease in the mean 20mSRT yield before 2010 (decadal trend (95% CI): -2.31 SD (-2.39, -2.24)), which decreased 0.06-fold to a negligible decrease after 2010 (decadal trend (95% CI): -0.15 SD (-0.20, -0.10)). Between 1999 and 2022, there was a small trend in distributional skewness, with slightly smaller declines experienced by high-performing participants (above the 75th percentile). The data suggest a significant decline in performance on the 20m test in French children and adolescents since 1999. This downward trend is attenuated since 2010. In contrast, other studies did not report secular declines in physical fitness in different populations. Andersen et al. (2010) reported no differences in maximal oxygen consumption rate (Vo^2max) in three different cohorts of Danish adolescents, assessed in 1983, 1997, 2003. Several systematic reviews inquired about changes in the physical fitness of United States (U.S.) Army infantry trainees between 1976-2015, indicating that there were no significant changes in physical attitude test performance over this period, a small improvement in abdominal performance and a decrease in performance in the two-mile run. Wyss et al. (2019) reviewed the physical fitness results of 306746 Swiss recruits, between 2006-2015 and reported that aerobic endurance and muscular power performance showed no secular changes over time, while balance decreased during this 10-year period.

The COVID-19 pandemic caused general confinement of the population worldwide throughout 2020, restricted the population of adolescents and young adults to attending academic activities while limiting the possibility of participating in physical or sports activities (Mata et al., 2024; Montoya Hurtado et al., 2024). This restriction on the practice of physical activities for adolescents and young people led to a large number of studies that analyzed the impact of the pandemic on physical fitness (Villodres et al., 2021; Wunsch, Kienberger & Niessner, 2022; Becerra Patiño et al., 2023; Cartes Alarcón et al., 2023; Eilertsen et al., 2024).

A retrospective study by Lee et al. (2022) used public data from the Korean Ministry of Education on 29,882 high school students (13-15-year olds: 14,941 males and 12,841 females) between 2019 and 2021. The variables that determined physical fitness were the following: BMI, 20 m shuttle run (20mSRT), grip strength, sit-and-reach, and speed over 50 m. The results of the study indicated that the COVID-19 pandemic had a negative impact as demonstrated by an increase in BMI and a significant decrease in cardiorespiratory resistance and grip strength. The authors highlight that adolescents' level of physical fitness was much lower after the COVID-19 pandemic than before.

In Japan (Kidokoro et al., 2023) a large study was conducted with 16 million schoolchildren aged 10 to 14 years old. The main objective of the study was to examine the temporal trends (2013-2021) of physical fitness in Japanese children and adolescents before and during the COVID-19 pandemic. The results indicated a significant decrease in performance in the 20mSRT and abdominal strength. This decrease was 18 to 15 times greater during the pandemic than the improvements seen before the pandemic.

All of these findings lead to the question of which of the two pandemics: COVID-19 or the secular decline in physical fitness, has had a greater impact on the decline in physical fitness in young people. Previous studies are inconclusive about fitness trends in young populations. Globally, information is available on different fitness trends by geographic region. To our knowledge, no information is available on secular trends in physical fitness among Colombian youth before and after the COVID-19 pandemic.

Therefore, the purpose of this study was to observe the temporal trends (2011-2022) of the physical fitness of a group of young Colombian adults before and after the pandemic. This is one of the few studies to cross-sectionally observe the evolution of physical fitness and the impact of COVID-19.

Material & methods

Methodology

This was a retrospective cross-sectional study with a quantitative approach (Setia, 2016), which collects and analyzes data on cardiorespiratory endurance, muscular power, flexibility and speed of young people in the city of Bogotá between 2011 and 2022 (2011 *n*=231; 2012 *n*=109; 2013 *n*=232; 2014 *n*=212; 2015 *n*=232; 2016 *n*=243; 2017 *n*=333; 2018 *n*=470; 2019 *n*=445; 2021 *n*=233; 2022 *n*=202) to estimate temporal trends.The data were obtained from evaluations each semester of young applicants to the sports degree program. The evaluations were conducted under the same standardized protocols by teachers of the program and at the same time, from 8:00 am to 12:00 pm. Each of the athletes signed the assent and the parents signed the informed consent of voluntary participation, in which the objective, scope and procedure of the study were explained in detail. Each procedure was developed under the principles established by the Helsinki declaration (World Medical Association, 2013) and resolution 8430 of the Colombian Ministry of Health (1993) was considered, declaring the study as low risk according to Colombian regulations from the standards and guidelines for research from non-invasive procedures.

Participants

This study used data from 2.942 applicants to the Bachelor of Sports program during the period 2011-2022. Of the sample, 79.76% were men (*n*= 2347) and 20.23% were women (*n*= 595), and the participants had an average age of 18.5±1.7 years. The data were acquired from records that are added every six months to the database of the sports degree program. We excluded participants whose test scores were equal to or greater than the 75th percentile. Before completing the tests, all applicants were informed of the objectives, risks and benefits and signed the informed consent form. In the case of minors, the legal persons responsible for the applicants provided informed consent.

Instruments

Physical fitness was assessed through a series of validated standardized indirect tests that are widely used internationally (Lovecchio et al., 2019). The tests were evaluated at different times by a group of experts in the application of these tests who used the same protocols and instruments according to a guide document written for this purpose. The participants received comprehensive instructions on the movements, and expert professors conducted demonstrations prior to the measurements.

Tests

Standing long jump (SLJ)

The objective of this test was to evaluate the explosive strength of the lower limbs. The participants performed a horizontal jump (systematic error of nearly 0) (Ortega et al., 2008) in an attempt to achieve the greatest distance. They started in a static standing position with their arms at their waists and jumped. The distance from the starting line to the heel of the foot closest to the line was measured. Two attempts were made, with a recovery time of 6 minutes between each jump. The highest value was recorded for the analyses.

Sit-and-Reach (SAR)

The European protocol was used (Bozic et al., 2010) to evaluate the flexibility of the lumbar and hamstring muscles (coefficient between classes = 0.98). The participants sat with their legs extended, hip-width apart, and bare feet supported by a height-adjustable step with a ruler. From this position, the participants slowly bent forward, stretching as far as possible to the furthest point on the ruler with both hands (one on top of the other) with knees fully extended, and held this position for 2 s. The distance reached to the farthest point of the ruler was recorded, which could be negative or positive. Two attempts were made, and the best one was used.

20 m Shuttle Run Test (20mSRT)

This test assessed cardiorespiratory endurance (Léger & Gadoury, 1989) and has shown good reliability in predicting VO^2max in young adults when the original equation is used (r = 0.71). The race is run back and forth over a distance of 20 m continuously. The speed is guided by a sound that, when emitted, means that the participant must be on one of the lines that demarcates a distance of 20 m. The participants were asked to start running when they heard the start signal and to reach the opposite point before the next beep. They continued running between points guided by the repeating beeps. The sound signal was emitted from a computer, and the sound was amplified so that it could be heard clearly by all participants. The number of complete stages performed by each participant was recorded.

Sprint 30 m (SP-30)

This test evaluated the explosive strength of the lower limbs. The participants performed a 30 m sprint on a flat surface (ICC = 0.96) (Papaiakovou et al., 2009). The participants were instructed to run at the fastest possible speed from the starting point to the 30 m finish point. They started in a standing position, and at the signal of the evaluator, they began the test. The units recorded were up to 0.01, and the measured values were rounded to the first decimal place. The time was recorded using a chronograph with a time resolution of 0.01 s. A maximum of two sprints were performed on the track with a recovery time of 6 minutes between them. The best time was used for the analyses. The specific warm-up included accelerations of 10, 15 and 20 m, and the test began at 3'.

Data analyses

All data are presented as the mean ± standard deviation (SD). The Shapiro–Wilk test was used to evaluate the normality distribution of the data. The temporal trends before (2011, 2019) and after (2022) the COVID-19

pandemic were analyzed using linear regression models. Second-order linear polynomial models were used because they naturally summarized the general temporal trends. A qualitative rating scale was used according to the magnitude of the observed correlation. Values less than 0.40 were considered weak, values between 0.41 and 0.60 were moderate, values between 0.61 and 0.80 were strong, and values between 0.81 and 1 were very strong. Repeated-measures ANOVA was performed to determine the differences between years (2011 to 2022) in men and women separately. Bonferroni's post hoc test (Agbangba et al., 2024) was applied if necessary to evaluate the interannual differences. The relevance of the change was estimated by calculating the effect size (ES) with eta squared ($\eta 2$), and Cohen's scale was used: 0.2 to 0.49 indicated a small effect size (Sullivan & Feinn, 2012), 0.5 to 0.79 indicated a moderate effect size, and 0.8 or greater indicated a large effect size. The level of significance was set at $p < 0.05$. All data were analyzed with SPSS version 25 (IBM-SPSS, Armonk, New York, USA).

Results

The present study consolidated the results obtained between the years 2011 to 2022 in the tests of maximum oxygen consumption, jump length, flexibility and running speed of 2.942 young adults with an average age of 19.8±0.5 years for women and 20.6±0.6 years for men. No significant differences were found in the age of the subjects evaluated during the observed periods for men or women. The data for 2020 are not available because, due to confinement, the evaluation tests were not conducted in the two periods of that year. Table 1 shows the distribution and characteristics of the population in each of the years analyzed.

Table 1.
Characteristics and distribution of the population between 2011-2022

	Men		Women	
	n	Age	*n*	Age
2010	188	20,8	43	19,6
2011	83	21,6	26	19,5
2012	180	20,9	52	20,4
2013	173	19,8	38	19,3
2014	186	21,2	46	20,7
2015	193	20,8	50	19,4
2016	265	19,7	68	19,2
2017	385	21,4	85	20,7
2018	338	20,4	107	20,3
2020	190	19,6	43	19,4
2022	165	20,9	37	19,6

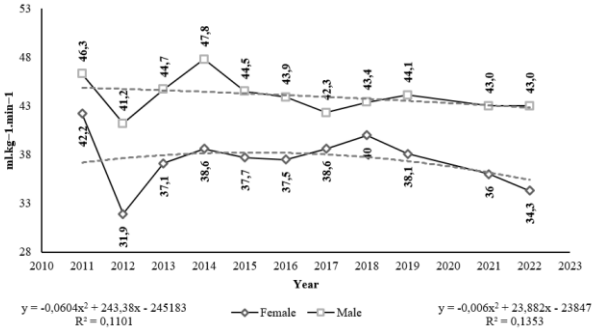

Figure 1. Temporal trend of peak oxygen consumption (ml·min·kg-1, mean, interval CI 95%) in men and women between 2011 and 2022.

Table 2.
Temporal trends in oxygen consumption, jump length, running time, and hamstring flexibility in Colombian young adult men and women before and after the COVID-19 pandemic.

Year	Sex	n	Shuttle Run				Standing Long Jump				Sit-and-Reach				30-m Sprint			
			ml/min/kg-1	%v	*p*-value	ES	cm	%v	*p*-value	ES	cm	%v	*p*-value	ES	s	%v	*p*-value	ES
2011	M	188	46.3±6.1				203.5±26.4				9.5±6.8				6.11±0.58			
	F	43	42.2±6.9				200.5±32				7.6±7.8				6.23±0.7			
2012	M	83	40.9±4.6	-11.7	0.000	0.99	210.3±23.0	-3.3			7.5±7.0	21.1			6.10±0.31	0.22		
	F	26	31.9±3.3	-24	0.000	1.45	159.0±16	-20.7	0.000	1.62	10.0±6.6	31			7.21±0.4	18	0.000	1.8
2013	M	180	44.7±5.0	-3.5			215.0±16.9	-5.7			9.1±6.9	4.5			6.19±0.39	-1.28		
	F	52	37.1±5.7	-12	0.001	0.85	162.8±18	-18.8	0.004	1.43	10.9±5.6	43			6.93±0.8	13		
2014	M	174	47.8±5.3	3.2			216.2±19.2	-6.2			4.8±6.5	49.1	0.001	0.62	6.40±0.68	-4.74		
	F	38	38.6±5.1	-9			172.6±16	-13.9			12.4±6.7	63			6.81±0.9	11		
2015	M	186	44.5±4.5	-3.9			208.2±16.6	-2.3			7.2±5.7	24.3			6.45±0.49	-5.33		
	F	46	37.7±4.8	-11			162.5±22	-18.9	0.000	1.36	10.5±6.2	37			7.41±0.5	21	0.000	2
2016	M	193	43.9±5.1	-5.2	0.004	0.45	211.5±22.7	-3.9			9.5±8.1	0.1			5.98±0.32	2.00		
	F	50	37.5±5.7	-11			160.8±20	-19.8	0.000	1.47	14.0±6.2	83			7.10±0.6	16	0.002	1.4
2017	M	265	42.3±6.4	-8.6	0.000	0.71	219.2±23.3	-7.7	0.010	0.07	7.5±8.1	21.3			5.85±0.52	4.41		
	F	68	38.6±5.3	-9			165.6±9.5	-17.4	0.001	1.46	12.1±6.5	58			7.18±0.7	17	0.001	1.5
2018	M	385	43.4±6.3	-6.3	0.006	0.46	201.1±21.5	1.2			6.2±6.2	34.3			6.13±0.63	-0.26		
	F	85	40.0±6.3	-5			158.1±20	-21.1	0.000	1.57	12.1±7.5	58			6.65±0.7	9		
2019	M	338	44.1±5.2	-4.8			205.9±23.3	-1.2			8.2±6.5	13.0			6.20±0.56	-1.51		
	F	107	38.1±3.9	-10			163.6±20	-18.4	0.001	1.37	6.4±7.5	17			6.39±0.5	3		
2021	M	190	43.0±6.0	-7.1	0.000	0.58	195.2±23.6	4.1			6.9±6.2	27.5			5.92±0.46	3.06		
	F	43	36.0±4.7	-15			154.5±19	-22.9	0.000	1.73	8.9±5.4	17			6.63±0.4	8		
2022	M	165	43.0±4.6	-7.1	0.000	0.54	182.7±27.5	10.2	0.000	0.10	9.7±6.7	-2.3			5.41±0.28	11.85	0.000	0.12
	F	37	34.3±3.4	-19	0.000	1.09	149.4±22	-25.5	0.000	1.86	12.5±5.0	64			6.81±0.6	11		

Notes: Temporal trends for shuttle run, standing long jump, sit-and-reach, 30-m sprint. mean ± SD, mean and standard deviation
Positive trends in means indicate temporal increases/improvements, and negative trends in means indicate temporal decreases. Abbreviations: %v=% of variation; ES = effect size; *p*-value: $p<0.05$.

Figure 2 shows the polynomial trend lines of a strong decrease ($R^2 = 0.83$) in the case of men and a moderate

decrease ($R^2 = 0.49$) in women in the length of the jump between 2011 and 2022.

The behavior of flexibility is heterogeneous in both men and women. In men, these variations range from 4.7 cm (49%) to 1.2 cm (13%), and in women, they range from 6.4 cm (83%) to 2.4 cm (17%). There are no significant differences, and there is only a moderately significant difference between 2011 and 2014 in the case of men. Figure 3 shows the polynomial trend lines in the Sit-and-Reach, which indicates a very weak decrease for men ($R^2 = 0.1$) and a very weak increase for women ($R^2 = 0.1$). Regarding running speeds over 30 meters, for men, a decrease in running time is observed without significant differences between the times of the participants in each period. The exception is between 2011 and 2022, when there is a small significant difference. For women, however, there are increases in running time with large significant differences between 2011 vs. 2012-2015-2016-2017, ranging from 0.2 sec (3%) to 1.3 sec (21%).

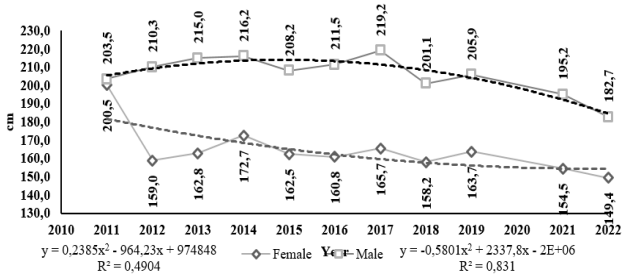

Figure 2. Temporal trend of the length of the jump (cm, mean, interval CI 95%) in men and women between 2011 and 2022.

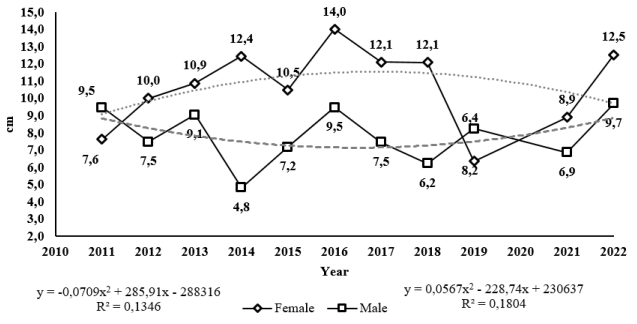

Figure 3. Temporal trend of flexibility (cm, mean, interval CI 95%) in men and women between 2011 and 2022.

Discussion

The purpose of this study was to identify the temporal trends (2011-2022) of the physical fitness of (maximum oxygen consumption, jump length, flexibility and running speed) group of 2.942 young Colombian men and women aged 17-21 before and after the COVID-19 pandemic. While flexibility performance shows a slight increase, maximal oxygen consumption, jump length and running speed reveal an overall trend of continuous decrease between 2011-2022 that is consistent with the global trend. According to the review of the literature and the findings of a recent meta-analysis (Kljajević et al., 2021), only a small number of studies have evaluated physical fitness in large population groups, and only three similar studies were identified that conducted this type of approach with young adults (Sun et al., 2023; Lee et al., 2022; Kidokoro et al., 2023).

Likewise, Amini et al. (2020) examined the physical activity of the Iranian population during the COVID-19 pandemic and found that 78% of participants did not meet PA guidelines during this period, in contrast to a prepandemic study that reported that approximately 33% of Iran's adult population did not meet standard PA guidelines (Guthold et al., 2018). In Brazil, 79.4% of adults reported that their level of physical activity decreased during the COVID-19 pandemic (Martinez et al., 2020). The results of most of these types of studies indicate a significant global decrease in PA levels along with an increase in SB during the COVID-19 pandemic (Arena et al., 2021). In the present study, the VO^2max consumption obtained in 2021-2022 (after the pandemic) was compared with the previous period of 2011-2019, and no significant differences were identified. This indicates, on the one hand, that the impact of confinement by COVID-19 on the decrease in maximum oxygen consumption was not greater than that produced by the silent pandemic of physical inactivity and sedentary behaviors.

20 m Shuttle Run Test (20mSRT)

The results of the present study reveal a slight decreasing trend in the maximum oxygen consumption between 2011 and 2022, the difference was 7.1% in men and 21.4% in women, which means a decrease in maximum oxygen consumption of 3.3 and 9.2 ml·min·kg-1 respectively. These results are in line with previous studies have also shown that physical fitness, particularly aerobic fitness, has decreased dramatically over the last 2 to 3 decades in young populations. Investigations of large population groups and long observation periods (10 years) that involved young adults from Estonia and Lithuania (Jürimäe et al., 2007), Spain (Matton et al., 2007) and Australia and New Zealand (Tomkinson & Olds, 2007) who reported decreased in the maximum oxygen consumption. In the United Kingdom, aerobic fitness decreased by 11% between 1998–9 and 2003–4 (Stratton et al., 2007). Population studies of young men (19 to 20 years of age) entering the military indicate that VO^2max values assessed at the start of military service have decreased between 8% and 12% during the last 2 to 3 decades (Dyrstad et al., 2005; Santtila et al., 2006) which corresponds to an approximate 4% decrease in each decade. A meta-analysis (Tomkinson et al., 2003) that retrieved information from 55 studies on the performance of children and adolescents aged 6 to 19 years in the 20-m shuttle run test (20mSRT) indicated that there was a significant decline in performance in the 11 countries for which data are available and in most age × sex groups, with a weighted average decrease per sample of 0.43% of the mean values per year. The decline was more marked in the older age groups, and the rate of

decline was similar for boys and girls. A more recent study developed by Vanhelst et al. (2024) in a population of 15420 French children and young people, observed a large decrease in mean 20 mSRT performance (decadal trend (95% CI): -1.42 SD (-1.45, -1.39) or -18.4 % (95% CI: -18.8, -18.0)) between 1999 and 2022.

The results of the present study contrast with studies such as (Lovecchio et al., 2020), which considered 11-year-old Italian children in the period 2004-2013 and identified stagnation or improvement in the Cooper Endurance Run Test, the Standing Broad Jump test, and the SP-30. One possible explanation for these differences may be that in most studies, including the present one, the shuttle run test was used rather than the Cooper endurance run test. The applicability of the latter has been criticized in nonathlete populations. Given the evidence from previous studies and the present study, the existence of a possible decline in the physical fitness of young adults can be suggested. This hypothesis is further supported by the extensive evidence obtained from various systematic reviews and meta-analyses

In the present study, the VO^2max consumption showed a small but steady downward trend, which may suggest a generalized influence over the last decade. In 2021-2022 (after the pandemic) was compared with the previous period of 2011-2019, and no significant differences were identified, this indicates, on the one hand, that the impact of confinement by COVID-19 on the decrease in maximum oxygen consumption was not greater than that produced by the silent pandemic of physical inactivity and sedentary behaviors. This information may be important for national health authorities and health professionals and provides evidence contrary to the belief that COVID-19 confinement was responsible for the decline in physical fitness in the youth population. Therefore, this consistent trend of declining fitness is discouraging and raises alerts for health systems to generate strategies that will lead to slowing and possibly reversing this situation.

In the same vein, some studies address the effects of COVID-19 confinement on the physical condition of juvenile populations. López-Bueno et al. (2021) studied a population of 12- to 14-year-old Spanish children using the 20-m shuttle run test to estimate VO^2max before and after COVID-19 confinement. They identified an overall decrease of -0.5 $ml.kg^{-1}.min^{-1}$ (SD 0.3) ($p = 0.12$). The group of 14-year-old girls presented the most significant reductions (-1.5 $ml.\ kg^{-1}.min^{-1}$ (SD 0.6) ($p < 0.05$)), 14-year-old boys showed a slight increase (0.4 $ml.kg^{-1}.min^{-1}$ (SD 0.5) ($p = 0.44$)), while 12-year-old boys showed a significant decrease (-1, 2 $ml.kg^{-1}.min^{-1}$ (SD 0.7) ($p = 0.14$)). These values are slightly lower than those reported in the present study of 1.6 $ml.kg^{-1}.min^{-1}$ in men and 2.4 $ml.kg^{-1}.min^{-1}$ in women. This greater decrease in women has been reported in several studies (Mielke et al., 2018; Guthold et al., 2018; López-Bueno et al., 2021). This may be because women are less active and comply with activity recommendations to a lesser extent than men (Guthold et al., 2018), as shown in a study conducted in 142 countries that verified that women were more inactive than men in all but eight countries (Mielke et al., 2018).

In Japan, a cross-sectional study of children and young adolescents between 2013 and 2021 (Kidokoro et al., 2023) found that the decrease in performance in the 20-m shuttle run test during the pandemic was 27 times greater than the international decrease between 2010 and 2014. However, it is important to note that this effect of the COVID-19 pandemic on the decrease in performance in the 20-m shuttle run test could be because in Japan, unlike other countries, organized sports are very popular in school settings, and most Japanese children and adolescents participate in organized sports at school (Tomkinson & Olds, 2007; Stratton et al., 2007; Dyrstad et al., 2005; Santtila et al., 2006).

Standing Long Jump (SLJ)

Regarding the temporal behavior of the SLJ in the present study, a decreasing trend was observed in women, reflected in a loss of 19.7% (39.49cm) over the period 2011-2022. These temporal reduction trends were reported in previous studies conducted in northern European countries (Jürimäe et al., 2007; Matton et al., 2007; and recently ratified by Tsoukos & Bogdanis (2022) compared the temporal behavior of the vertical jump test, SP-30 m and agility in 15-year-old Greek adolescents and observed a significant decrease in these capacities in both sexes after confinement compared to the 2016-2017 and 2018-2019 cohorts (vertical jumps: 10.4-15.1%; $p < 0.01$; d = 0.58-1.01, 30 m sprint: 3.7-4.9%; $p < 0.01$; d = 0.62-0.74; 505 agility test: 6.1% to 9.4%; $p < 0.01$; d = 0.80-1.04). In contrast, in males, a discrete continuous increase in jump length (3.6%-7.33cm) is observed between 2011 and 2019, and a 7.5% decrease (15.3cm) between 2021-2022. These data are consistent with the findings of Tomkinson et al. (2007).

Very few studies have examined how neuromuscular fitness has changed over the past decades in the young adult population, which is why this topic remains controversial (Kyröläinen et al., 2010). It is important to note that although this decrease is not statistically significant, it is clinically significant because regardless of how minimal the loss of physical fitness is, it has a negative effect on health and increases the risk of chronic noncommunicable diseases and mortality. For example, several studies report a loss of strength (McLeod et al., 2016; Momma et al., 2022). Another study determined that it is necessary to develop intervention and monitoring programs for university students, seeking to recognize spaces that favor a lifestyle conducive to improving the physical condition (Becerra Patiño et al., 2024). Another study (Kubieva et al., 2019) concluded that college students have problems with body mass index and strength regardless of their level of physical activity.

Sprint 30 m (SP-30)

In the present study, the temporal behavior of this test presented a gradual loss of 13% (0.69s) in the group of women during the period 2011-2022. On the contrary, in

men the behavior was not homogeneous. In the periods 2011-2015; 2018-2019 presented an increase in test time of 3.9%, in 2016-2017; 2021-2022 an improvement of 5.2%. Unfortunately, there are not many studies available that analyze the temporal behavior of this test and the results are heterogeneous. The studies by Vandoni et al. (2022), Lovecchio et al. (2020), Gallotta et al. (2009) did not observe significant changes in the times of the 30 m run. On the contrary, the systematic review by Masanovic et al. (2020) which took data from Greece 1997 to 2007; Spain, 2001 to 2007; Germany 2007-2015, indicated a general improvement in speed performance and Eberhardt et al. (2020) stated a stagnation of the results.

These decreases in speed and power performance could be attributed to reductions in muscle fiber cross-sectional area (muscle factor) and altered central activation (neural factor) as a result of inactivity (Bogdanis, 2012) which has been shown to decrease the production of electromyographic force and activity (Mujika & Padilla, 2001). Very few studies have examined how neuromuscular fitness has changed over the past decades in the young adult population, which is why this topic remains controversial (Kyröläinen et al., 2010).

Sit-and-Reach (SAR)

Traditionally, this test has revealed poor performance worldwide in all age groups investigated. In the present study, an average temporal decrease of 21.7% (2.09cm) between 2011-2022 was observed in the male group, on the contrary, in the female group a temporal increase of 44% (3.41cm) was presented, without being overall significant in either case. Previous international studies such as that of Lovecchio (2019) who collected data from more than 32,000 students aged 11-14 years in six countries in Europe, or those of Hanssen-Doose (2020) or Colley et al. (2019) in Canada, indicated a stabilization in the performance of this test. In the review by Eberhardt et al, a study from Greece revealed a positive secular trend (1992-2007) with an increase of 22% and 13% for boys and girls, respectively.

It is important to note that although decreased performance is not statistically significant in most cases,it is has a negative effect on health and increases the risk of chronic noncommunicable diseases and mortality. In addition to the evidence presented above, the results of the present study indicate that over the years, the population of young adults has experienced a decrease in physical fitness. It is important to conduct more studies that cross-examine the temporal behavior of physical fitness factors to consolidate more objective evidence, identify behavioral trends and predict possible outcomes in the field of health. The evaluation of physical fitness is crucial to define the general state of health of young people, and it is important in continuing to develop a concrete plan toward an active lifestyle.

Conclusions

The results of this study indicate a gradual and sustained reduction in the physical fitness of young adults throughout the past decade, which was greater than that caused by confinement due to the COVID-19 pandemic. This indicates that the level of physical fitness is so low that confinement did not generate significant effects on the reduction in physical fitness in the young adult population. In other words, the silent pandemic of physical inactivity and sedentary behaviors has had a greater effect than COVID-19 on levels of physical inactivity and sedentary behaviors.

Competing interests

The authors declare that they have no competing interests.

References

Agbangba, C.E., Eide, E.S., Honfo, H., & Glèlè Kakai, R. (2024). On the use of post-hoc test in environmental and biological sciences: A critical review. *Heliyon, 10*(3): e25131. https://doi.org/10.1016/j.heliyon.2024.e25131

Amini, H., Isanejad, A., Chamani, N., Movahedi-Fard, F., Salimi, F., Moezi, M., et al. (2020). Physical activity during COVID-19 pandemic in the Iranian population: A Brief Report. *Heliyon, 6*(11):e05411. doi: 10.1016/j.heliyon.2020.e05411

Andersen, L.B., Froberg, K., Kristensen, P.L., Moller, N.C., Resaland, G.K., & Anderssen, S.A. (2010). Secular trends in physical fitness in Danish adolescents. *Scandinavian Journal of Medicine & Science in Sports, 20*(5), 757-63. doi: 10.1111/j.1600-0838.2009.00936.x.

Arena, R., Hall, G., Laddu, D.R., Phillips, S.A., & Lavie, C.J. (2022). A tale of two pandemics revisited: Physical inactivity, sedentary behavior and poor COVID-19 outcomes reside in the same Syndemic City. *Progress in Cardiovascular Diseases, 71*:69-71. doi: 10.1016/j.pcad.2021.11.012

Becerra Patiño, B. A., Nieto Rodríguez, G. F., Martínez Ospina, E.G., Riaño López, E. S., & Dimas Correa, D. S. (2023). Evaluation of motor coordination in 9-year-old Colombian infants postconfinement by COVID-19: gender related, sociodemographic context and sport. *Retos, 48*, 6–15. https://doi.org/10.47197/retos.v48.95096

Becerra Patiño, B. A., Reina, C. J., Martínez-Benitez, C. F., Paucar Uribe, J. D., Montilla Valderrama, V., Cárdenas-Contreras, S., Castro Malaver, M. A., Varón Murcia, J. J., & Ávila Martínez, J. D. (2024). Relationship of learning to learn competence, lifestyles and physical fitness in Colombian university sports students: An exploratory study. *Retos, 51*, 58–68. https://doi.org/10.47197/retos.v51.100442

Bogdanis, G.C. (2012). Effects of physical activity and

inactivity on muscle fatigue. *Frontiers in Physiology*, 3:142. doi: 10.3389/fphys.2012.00142

Booth, F.W., Roberts, C.K., & Laye, M.J. (2012). Lack of exercise is a major cause of chronic diseases. *Comprehensive Physiology, 2*(2), 1143-211. doi: 10.1002/cphy.c110025.

Bozic, P.R., Pazin, N.R., Berjan, B.B., Planic, N.M., & Cuk, I.D. (2010). Evaluation of the field tests of flexibility of the lower extremity: reliability and the concurrent and factorial validity. *Journal of Strength and Conditioning Research*, *24*(9), 2523-31. doi: 10.1519/JSC.0b013e3181def5e4

Cartes Alarcón, C., Godoy Riquelme, K., Jiménez Sáez, C., Arriagada Hernández, C., & Fuentes-Vilugrón, G. (2023). Effect produced by physical activity and inactivity during covid-19 according to physical education pedagogy students. *Retos*, *49*, 126–134. https://doi.org/10.47197/retos.v49.96754

Colley, R.C., Clarke, J., Doyon, C.Y., Janssen, I., Lang, J.J., Timmons, B.W., & Tremblay, M.S. (2019). Trends in physical fitness among Canadian children and youth. *Health Reports, 30*(10), 3-13. doi: 10.25318/82-003-x201901000001-eng

Dyrstad, S. M., Aandstad, A., & Hallén, J. (2005). Aerobic fitness in young Norwegian men: a comparison between 1980 and 2002. *Scandinavian Journal of Medicine & Science in Sports, 15*(5), 298-303. doi:10.1111/j.1600-0838.2005.00432.x

Eberhardt, T., Niessner, C., Oriwol, D., Buchal, L., Worth, A., & Bös, K. (2020). Secular Trends in Physical Fitness of Children and Adolescents: A Review of Large-Scale Epidemiological Studies Published after 2006. *International Journal of Environmental Research and Public Health,* 7(16):5671. doi: 10.3390/ijerph17165671.

Eilertsen, M., Riis, A., Nielsen, A., & Riel, H. (2024). Physical activity levels before and after the COVID-19 restrictions among Danish adolescents: a retrospective cohort study. *Scandinavian Journal of Public Health*, 52(3), 284-289. doi:10.1177/14034948231201690

Gallotta, M.C., Marchetti, R., Baldari, C., Guidetti, L., & Pesce, C. (2009). Linking coordinative and fitness training in physical education settings. *Scandinavian Journal of Medicine & Science in Sports*, *19*(3), 412-418. doi: 10.1111/j.1600-0838.2008.00796.x

Guthold, R., Stevens, G.A., Riley, L.M., & Bull, F.C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health, 6*(10):e1077-e86. doi: 10.1016/S2214-109X(18)30357-7

Hanssen-Doose, A.; Niessner, C.; Oriwol, D.; Bös, K.;Woll, A.;Worth, A. Population-based trends in physical fitness of children and adolescents in Germany, 2003–2017. *European Journal of Sport Science, 21*(8), 1204-1214. doi: 10.1080/17461391.2020.1793003.

Jürimäe, T., Volbekiene, V., Jürimäe, J., & Tomkinson, G. R. (2007). Changes in Eurofit test performance of Estonian and Lithuanian children and adolescents (1992-2002). *Medicine and Sport Science, 50*, 129-142. doi:10.1159/000101356

Kidokoro, T., Tomkinson, G.R., Lang, J.J., & Suzuki, K. (2023). Physical fitness before and during the COVID-19 pandemic: Results of annual national physical fitness surveillance among 16,647,699 Japanese children and adolescents between 2013 and 2021. *Journal of Sport and Health Science, 12*(2), 246-54. https://doi.org/10.1016/j.jshs.2022.11.002

Kljajević V, Stanković M, Đorđević D, Trkulja-Petković D, Jovanović R, Plazibat K, Oršolić M, Čurić M, Sporiš G. Physical Activity and Physical Fitness among University Students-A Systematic Review. *International Journal Environmental Research and Public Health*, *19*(1), 158. doi: 10.3390/ijerph19010158.

Kubieva, S.S.B., Konisbaeva, S.I., Mambetov, N., Aralbayev, A.S., Zhetimekov, Y.T., Dairabayev, S.E., et al. (2019). Health promotion program for the students with regard to the level of their physical activity, physical fitness and health. *Journal of Physical Education and Sport, 19*, 703-709. doi:10.7752/jpes.2019.01101

Kyröläinen, H., Santtila, M., Nindl, B. C., & Vasankari, T. (2010). Physical fitness profiles of young men: associations between physical fitness, obesity and health. *Sports Medicine, 40*(11), 907-920. doi:10.2165/11536570-000000000-00000

Lee, K.J., Seon, S.Y., Noh, B., & An K.O. (2022). Physical fitness changes in adolescents due to social distancing during the coronavirus disease pandemic in Korea. *PeerJ*, 10:e14494. doi: 10.7717/peerj.14494

Léger, L., & Gadoury, C. (1989). Validity of the 20 m shuttle run test with 1 min stages to predict Vo2max in adults. *Canadan Journal of Sport Sciences, 14*(1), 21-6.

López-Bueno, R., Calatayud, J., Andersen, L.L., Casaña, J., Ezzatvar, Y., Casajús, J.A., et al. (2021). Cardiorespiratory fitness in adolescents before and after the COVID-19 confinement: a prospective cohort study. *European Journal of Pediatrics, 180*(7), 2287-93. doi: 10.1007/s00431-021-04029-8

Lovecchio, N., Novak, D., Sedlacek, J., Hamar, P., Milanovic, I., Radisavljevic-Janic, S., Emeljanovas, A., Eid, L., & Zago, M. (2019). Physical fitness for sedentary students: a common trend from six European countries. *The Journal of Sports Medicine and Physical Fitness, 59*(8), 1389-96. doi: 10.23736/S0022-4707.18.08926-0.

Lovecchio, N., Giuriato, M., Carnevale Pellino, V., Valarani, F., Codella, R., & Vandoni, M. (2020). Italian Physical Fitness Decline: A True Fact or a Mindset? A 10-Year Observational Perspective Study. *International Journal of Environmental Research and Public Health*, *17*(21). doi:10.3390/ijerph17218008

Macfarlane, D.J., & Tomkinson, G.R. (2007). Evolution

and variability in fitness test performance of Asian children and adolescents. *Medicine and Sport Science, 50*, 143-167. doi: 10.1159/000101358.

Martinez, E.Z., Silva, F.M., Morigi, T.Z., Zucoloto, M.L., Silva, T.L., Joaquim, A.G., et al. (2020). Physical activity in periods of social distancing due to COVID-19: a cross-sectional survey. *Ciencia & Saude Coletiva 25*(suppl 2), 4157-68. doi: 10.1590/1413-812320202510.2.27242020

Masanovic, B., Gardasevic, J., Marques, A., Peralta, M., Demetriou, Y., Sturm, D.J., & Popovic S. (2020). Trends in Physical Fitness Among School-Aged Children and Adolescents: A Systematic Review. *Frontiers in Pediatrics,* 8:627529. doi: 10.3389/fped.2020.627529.

Mata, C., Onofre, M., Papaioannou, A., & Martins, J. (2024). Autopercepciones de salud, satisfacción con la vida y vitalidad subjetiva de los adolescentes durante la pandemia de COVID-19: un análisis basado en el nivel educativo, género y el estado de actividad física. (Adolescents' self-perceived health, life satisfaction and subjective vitality during the COVID-19 pandemic: an analysis based on education level, gender and physical activity status). *Retos, 57,* 399–406. https://doi.org/10.47197/retos.v57.104528

Matton, L., Duvigneaud, N., Wijndaele, K., Philippaerts, R., Duquet, W., Beunen, G., . .. Lefevre, J. (2007). Secular trends in anthropometric characteristics, physical fitness, physical activity, and biological maturation in Flemish adolescents between 1969 and 2005. *American Journal of Human Biology, 19*(3), 345-357. doi:10.1002/ajhb.20592

McLeod, M., Breen, L., Hamilton, D.L., & Philp, A. (2016). Live strong and prosper: the importance of skeletal muscle strength for healthy ageing. *Biogerontology, 17*(3), 497-510. doi: 10.1007/s10522-015-9631-7.

Mielke, G.I., da Silva, I.C.M., Kolbe-Alexander, T.L., Brown, W.J. (2018). Shifting the Physical Inactivity Curve Worldwide by Closing the Gender Gap. *Sports Medicine, 48*(2), 481-9. doi: 10.1007/s40279-017-0754-7

Ministry of Health of Colombia. (1993). Resolution number 8430. Retrieved from https://cutt.ly/UKTTDh6

Momma, H., Kawakami, R., Honda, T., & Sawada, S.S. (2022). Muscle-strengthening activities are associated with lower risk and mortality in major non-communicable diseases: a systematic review and meta-analysis of cohort studies. *British Journal of Sports Medicine, 56*(13), 755-763. doi: 10.1136/bjsports-2021-105061.

Montoya Hurtado, O.L., Cañón Buitrago, S., Bermúdez Jaimes, G., Gómez Jaramillo, N., Correa Ortiz, L. C., & Rosenbaum, S. (2024). Niveles de actividad física y sedentarismo en estudiantes universitarios Colombianos y Mexicanos: Un estudio descriptivo transversal (Physical activity and sedentary lifestyle in Colombian and Mexican university students: A cross-sectional descriptive study). *Retos, 54*, 114–121. https://doi.org/10.47197/retos.v54.100234

Mujika, I., & Padilla, S. (2001). Muscular characteristics of detraining in humans. *Medicine and Science in Sports and Exercise, 33*(8), 1297-303. doi: 10.1097/00005768-200108000-00009

Ortega, F.B., Artero, E.G., Ruiz, J.R., Vicente-Rodriguez, G., Bergman, P., Hagströmer, M., et al. (2008). Reliability of health-related physical fitness tests in European adolescents. The HELENA Study. *International Journal of Obesity* (Lond), *32*(5):S49-57. doi: 10.1038/ijo.2008.183

Papaiakovou, G., Giannakos, A., Michailidis, C., Patikas, D., Bassa, E., Kalopisis, V., et al. (2009). The effect of chronological age and gender on the development of sprint performance during childhood and puberty. *Journal of Strength and Conditioning Research, 23*(9), 2568-73. doi: 10.1519/JSC.0b013e3181c0d8ec

Park, J.H., Moon, J.H., Kim, H.J., Kong, M.H., & Oh, Y.H. (2020). Sedentary Lifestyle: Overview of Updated Evidence of Potential Health Risks. *Korean Journal of Family Medicine, 41*(6), 365-373. doi: 10.4082/kjfm.20.0165.

Pinoniemi, B.K., Tomkinson, G.R., Walch, T.J., Roemmich, J.N., & Fitzgerald, J.S. (2020). Temporal Trends in the Standing Broad Jump Performance of United States Children and Adolescents. *Research Quarterly for Exercise and Sport, 92*(1), 71-81. doi: 10.1080/02701367.2019.1710446.

Santtila, M., Kyröläinen, H., Vasankari, T., Tiainen, S., Palvalin, K., Häkkinen, A., & Häkkinen, K. (2006). Physical fitness profiles in young Finnish men during the years 1975-2004. *Medicine and Science in Sports and Exercise, 38*(11), 1990-1994. doi:10.1249/01.mss.0000232023.28984.78

Setia MS. (2016). Methodology Series Module 3: Cross-sectional Studies. *Indian Journal of Dermatology, 61*(3), 261-4. doi: 10.4103/0019-5154.182410.

Stratton, G., Canoy, D., Boddy, L. M., Taylor, S. R., Hackett, A. F., & Buchan, I. E. (2007). Cardiorespiratory fitness and body mass index of 9-11-year-old English children: a serial cross-sectional study from 1998 to 2004. *International Journal of Obesity (Lond), 31*(7), 1172-1178. doi:10.1038/sj.ijo.0803562

Sullivan, G.M., & Feinn, R. (2012). Using Effect Size-or Why the P Value Is Not Enough. *Journal of Graduate Medical Education, 4*(3), 279-82. doi: 10.4300/JGME-D-12-00156.1

Sun, J., Chang, J., Zhu, E., Sun, X., Tao, Y., & Chen, X. (2023). Comparative research on the development of college students' physical fitness based on online physical education during the COVID-19 pandemic. *BMC Public Health, 23*. doi:10.1186/s12889-023-15599-7

Tomkinson, G.R., Léger, L.A., Olds, T.S., & Cazorla, G. (2003). Secular trends in the performance of children and adolescents (1980-2000): an analysis of 55 studies

of the 20m shuttle run test in 11 countries. *Sports Medicine, 33*(4), 285-300. doi:10.2165/00007256-200333040-00003

Tomkinson, G.R., & Olds, T.S. (2007). Secular changes in aerobic fitness test performance of Australasian children and adolescents. *Medicine and Sport Science, 50*, 168-182. doi:10.1159/000101361

Tomkinson, G.R., Olds, T.S., & Borms, J. (2007). Who are the Eurofittest? *Medicine and Sport Science, 50*, 104-128. doi: 10.1159/000101355.

Tomkinson, G.R., Kaster, T., Dooley, F.L., Fitzgerald, J.S., Annandale, M., Ferrar, K., Lang, J.J., & Smith, J.J. (2021). Temporal Trends in the Standing Broad Jump Performance of 10,940,801 Children and Adolescents Between 1960 and 2017. *Sports Medicine, 51*(3), 531-548. doi: 10.1007/s40279-020-01394-6.

Tsoukos, A., & Bogdanis, G.C. (2022). The Effects of a Five-Month Lockdown Due to COVID-19 on Physical Fitness Parameters in Adolescent Students: A Comparison between Cohorts. *International Journal of Environmental Research and Public Health*, *19*(1), 326. https://doi.org/10.3390/ijerph19010326

Vandoni, M., Carnevale Pellino, V., De Silvestri, A., Lovecchio, N., Rovida, A., Gatti, A., Biagioli, V., Zuccotti, G., & Calcaterra, V. (2022). The Temporal Association between Body Characteristics and Speed Performance over Twenty-Five Years in Italian Adolescents. *Children (Basel), 9*(4):521. doi: 10.3390/children9040521.

Vanhelst, J., Lang, J.J., Matelot, D., Carré, F., Mercier, D., Ulmer, Z., Oppert, J.M., Baquet, G., Berthoin, S., Fillon, A., Béghin, L., & Tomkinson, G.R. (2024). Cardiorespiratory fitness has declined among French children since 1999, although the decline appears to be getting smaller. *Scandinavian Journal of Medicine & Science in Sports*, *34*(5):e14641. doi: 10.1111/sms.14641.

Villodres, G.C., García-Pérez, L., Corpas, J.M., & Muros, J.J. (2021). Influence of Confinement Due to COVID-19 on Physical Activity and Mediterranean Diet Adherence and Its Relationship with Self-Esteem in Pre-Adolescent Students. *Children (Basel), 8*(10):848. doi: 10.3390/children8100848.

Westerstahl, M., Barnekow-Bergkvist, M., Hedberg, G., & Jansson, E. (2003). Secular trends in body dimensions and physical fitness among adolescents in Sweden from 1974 to 1995. *Scandinavian Journal of Medicine & Science in Sports*, *13*(2), 128-37. doi: 10.1034/j.1600-0838.2003.10274.x.

Wunsch, K., Kienberger, K., & Niessner, C. (2022). Changes in Physical Activity Patterns Due to the Covid-19 Pandemic: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research and Public Health, 19*(4):2250. doi: 10.3390/ijerph19042250.

Wyss, T., Roos, L., Studer, F., Mäder, U., Beuchat, C., & Staub, K. (2019). Development of physical fitness performance in young Swiss men from 2006 to 2015. *Scandinavian Journal of Medicine & Science in Sports*, *29*(4), 586-596. doi: 10.1111/sms.13376.

World Medical Association. (2013). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA, 310*(20), 2191-4. doi: 10.1001/jama.2013.281053.

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