Original Article

Tracking of physical fitness levels from childhood and adolescence to adulthood: a systematic review and meta-analysis

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Background: Prospective and large studies indicate that high physical fitness levels during young are beneficial for health during adulthood. The aim of the study was to investigate the tracking of physical fitness components from childhood and/or adolescence to adulthood.

Methods: Two authors systematically searched MEDLINE and Web of Science electronic databases for relevant articles. Studies with apparently healthy youth aged 6–18 years who track their physical fitness to adulthood were included. Our study carried out according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Correlation coefficients (r) were used as effect size. Random-effects models were used to estimate the pooled effect size. Correlation coefficients were interpreted as follows: <0.30 low stability, 0.30 to 0.60 moderate stability, and >0.60 high stability. Risk of bias of each study was determined by The Quality Assessment Tool for Observational Cohort and Cross-sectional Studies.

Results: Twenty-one prospective studies were included in the meta-analysis (n=6,197 participants at follow-up, 47.4% women). The mean length of follow-up was 20.8 years. Overall, cardiorespiratory fitness (r=0.38; 95% CI: 0.29–0.48; I^2=92.7%), muscular strength (r=0.51; 95% CI: 0.43–0.59; I^2=87.9%), and muscular endurance (r=0.50; 95% CI: 0.36–0.86; I^2=94.5%) show moderate tracking from childhood and/or adolescence to adulthood, independent of test used and length of follow-up. This moderate tracking was slightly stronger in women than in men and from adolescence compared to childhood. Trunk flexibility component, assessed with the sit and reach test, exhibits high stability (r=0.69; 95% CI: 0.58–0.81; I^2=92.9%). Interestingly, meta-regression analysis shows positive association between correlation coefficient for flexibility and the length of follow-up (β =0.017; 95% CI: 0.012–0.021).

Discussion: Although the current study found inconsistency between results, the findings suggest that acquiring high physical fitness levels should be targeted already from childhood and adolescence given that low levels of fitness in adulthood are related with several chronic diseases and mortality.

Trial Registration: Registration number CRD42021279143.

Keywords: Stability; muscular fitness; cardiorespiratory fitness; flexibility

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Introduction

A growing body of epidemiological and clinical evidence has examined the relationship between physical fitness and health outcomes across the life course. Acquiring and maintaining satisfactory fitness levels throughout life seem to be important, since these components are related with protection from risks to develop several chronic diseases. Overall, findings in adults show that greater physical fitness, mainly cardiorespiratory endurance and muscular fitness, is associated with reduced all-cause mortality (1,2) and risk of developing a wide range of non-communicable diseases (3), independent of potential confounding variables. In the same way, evidence in the scientific literature highlights the importance of acquiring adequate levels of the components of physical fitness from early years (4) since these are related to better body composition and a healthier cardiometabolic profile later in life (5,6).

Tracking refers to the maintenance of relative position within a group over time for at least two points in time (7). Longitudinal data for physical fitness through childhood, adolescence, and adulthood are not fully known yet. Differences in the type of physical fitness tests, follow-up, the initial age at baseline (i.e., childhood or adolescence), and different statistical models taken, make difficult to draw any conclusions. Generally interage show higher stability than for indicators of physical activity (7). Seems to be important to identify risk factors from childhood and adolescence for low physical fitness later in adulthood to offer solutions and prevent an unhealthy deterioration (8).

As explained earlier, given the importance of childhood and adolescence fitness relative to subsequent adult health outcomes, it is valuable to examine how comprehensive fitness components track throughout childhood and/or adolescence to adulthood. To explore if targeting childhood and adolescence physical fitness could help improve future health, a meta-analytic approach quantifying how levels of physical fitness track across the life course is needed. Therefore, the aim of the study was to determine the tracking of physical fitness components from childhood and/or adolescence to adulthood. We present the following article in accordance with the PRISMA reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-21-507/rc).

Methods

The protocol was registered in PROSPERO (the international prospective register of systematic reviews) (CRD42021279143). Each part of the systematic review (i.e., literature selection, data extraction) was performed by two authors (AGH & RRV) and disagreements were resolved through consultation with a third author (MI).

Selection criteria

Longitudinal cohort studies that measured physical fitness in childhood and/or adolescence (ages 6–18 years) and its prospective association in adulthood (age 20 years and over) were eligible. Any measure of physical fitness was considered. Where multiple studies reported on the same participants (i.e., same cohort), the paper judged to contain recent data or when all data results are available, was used.

Information sources and search strategy

MEDLINE and Web of Science electronic databases were searched for articles from inception to 5 October 2021. An example of electronic search strategy used in MEDLINE was as follows: ((((((((((physical fitness) OR (muscular strength)) OR (muscular fitness)) OR (cardiorespiratory fitness)) AND (aerobic fitness)) OR (flexibility)) AND (tracking)) OR (stability)) AND (cohort)) AND (longitudinal)) AND (prospective). Additionally, searches strategies were limited to children and adolescents aged 6–18 years.

Selection process and data collection process

Two authors independently obtained the following data from each article: (I) study characteristics (authors and publication year, sample size, sex, age of individuals, country, years of follow-up); (II) physical fitness details [test used, component of physical fitness (i.e., cardiorespiratory fitness, muscular endurance, muscular strength, and/or flexibility)]; and (III) analysis and results.

Risk of bias in individual studies

Quality Assessment Tool for Observational Cohort and Cross-sectional Studies (9) was used to determine the quality of each study. This scale is comprised of 14 items classified as “yes”, “no” or “not reported”.

Statistical analysis

The effect sizes reported by studies were correlations coefficients (r). DerSimonian-Laird random-effects inverse-variance model (10) was used using the Stata 17.0 (StataCorp, College Station, TX, USA). According to Malina (11), coefficient of correlation can be interpreted as follows: <0.30 low stability, 0.30 to 0.60 moderate stability, and >0.60 high stability. We considered a P value of <0.05 to be statistically significant.

It is important to clarify the following aspects relating to our statistical analyses: (I) pooled analysis (i.e., meta-analyses) were only performed for fitness parameters that were included in three or more articles; (II) when different sexes were included in a study, their data were analyzed independently; (III) when two or more tests for measuring the same fitness components (e.g., muscular strength) were included in an article, we included the higher correlation coefficient; and (IV) data from multiple articles of the same cohort were extracted and reported as a particular study, except there was no overlap.

Synthesis of results

For each analysis, heterogeneity across correlation coefficients was determined using the total variance and the inconsistency index (I^2) (12). I^2 values of <25%, 25–75%, and >75% were classified as small, moderate, and high heterogeneity, respectively (13).

Risk of bias across studies

The Luis Furuya-Kanamori (LFK) index was used to examine small-study effects and publication bias, respectively. An LFK value >1 or less than <−1 suggests minor asymmetry and a value greater >2 or <−2 suggests major asymmetry (14).

Additional analysis

Whenever possible, sub-group analysis according to sex, physical fitness test, and age at baseline (i.e., childhood or adolescence) were examined. Finally, random-effects meta-regression (DerSimonian and Laird model) was conducted to determine whether length of follow-up (years) was a moderator in these associations, showing the unstandardized regression coefficients (β).

Results

Study selection

Through database searching we identified 7,044 records. Of these, 5,635 studies were excluded by duplication. We screened 28 full-text articles and seven was excluded.

The reasons for exclusion were inappropriate study population (three studies) (15-17) or duplicate results (four studies) (18-21). In total, 21 studies met the inclusion criteria, but only 19 were included in the meta-analysis due to missing data in two of them. The PROSPERO flow diagram is shown in *Figure 1*.

Study characteristics

Our study included a total of 6,197 participantes (47.4% women). All articles included men and women with the exception of two studies that included only men (22,23) and another only women (24). Sample sizes ranged from 45 (25) to 822 (26) and length of follow-up from 7 (27) to 45 years (28) (mean: 20.8 years). Studies tracked the fitness components from childhood (29-31), adolescence (22-25,27,32-40), or both (26,28,41,42) to adulthood (*Table 1*).

Physical fitness measurement

Cardiorespiratory fitness was mainly determined with laboratory tests [e.g., maximal (23,25,28,32-34,36,38,39) or submaximal (37) test on a cycloergometer or treadmill with spirometry to determine oxygen consumption (VO_2), and the physical work capacity at a heart rate of 150 (42) or 170 beats per minute cycloergometer test (29)] or field tests [e.g., 20-m shuttle run test (22,27), 9-min run test (31,35), 12-min endurance test (40), 50-m shuttle run (24)] (*Table 1*).

Regarding muscular fitness (*Table 1*), most of the studies assessed muscular strength using the handgrip test (23,25,26,29,30,35,41) and explosive test such as the standing long jump (41), vertical jump (22-24,40), or sargent jump (37). Muscular endurance was assessed using mainly the sit-up test (23,25,29,31,37) and bent arm hang test (22-24,40). Other studies used an isometric strength score (38) and other tests different from those mentioned (*Table 1*).

Finally, flexibility was assessed using the sit and reach test in all included studies.

Risk of bias within studies

All studies met at least eight criteria (between 8 and 11 criteria) with an average of 8.8. Overall, studies could be considered to have low-moderate risk of bias. All 21 studies satisfied items 1, 2, 4, 6, 7, 8, and 11. In contrast, only eight studies fulfilled item 3 (regarding participation rate), six item 10 (regarding exposure assessed more than once over time),

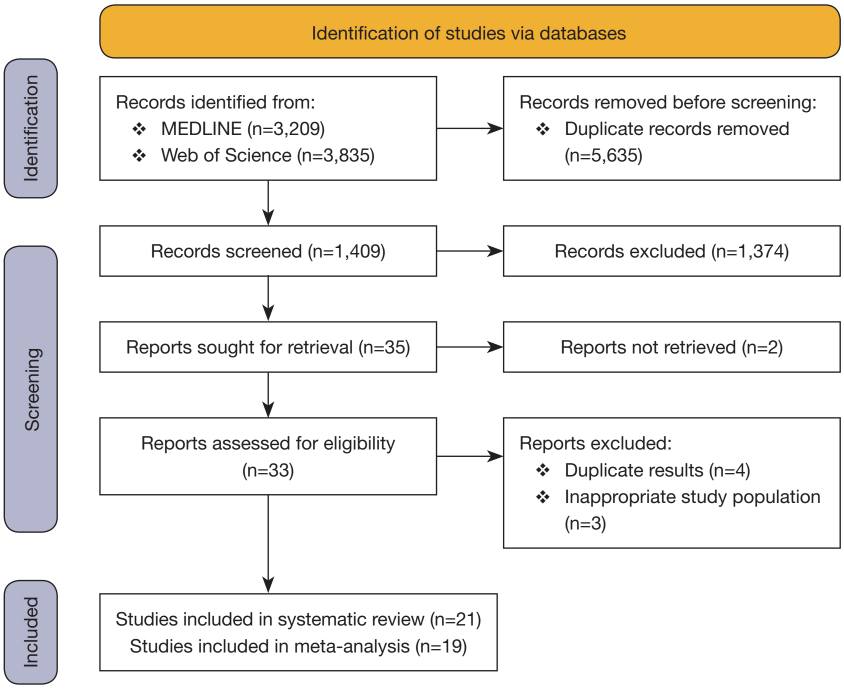

Figure 1 PRISMA flow diagram.

four item 13 (regarding loss to follow-up), and no studies fulfilled items 5 (regarding sample size justification) and 14 (regarding potential confounding) (*Table 2*).

Meta-analysis

Cardiorespiratory fitness

Our meta-analysis shows that cardiorespiratory fitness has moderate track from childhood and/or adolescence to adulthood (r=0.38; 95% CI: 0.29–0.48; I^2=92.7%) (*Figure 2*), with similar results according to sex (men: r=0.31, 95% CI: 0.24–0.39, I^2=51.2%; women: r=0.40, 95% CI: 0.34–0.45, I^2=9.9%), test used (maximal cycloergometer test: r=0.49, 95% CI: 0.33–0.64, I^2=92.0%; maximal treadmill test: r=0.33, 95% CI: 0.23–0.42, I^2=0%), and age at baseline (childhood: r=0.38, 95% CI: 0.26–0.49, I^2=27.8%; adolescence: r=0.41, 95% CI: 0.27–0.54, I^2=93.7%).

The meta-regression analysis showed that the length of follow-up did not moderate this association (β =–0.001; 95% CI: –0.010 to 0.009; P=0.863).

Major asymmetry suggestive of small-study effects was observed (LKF index =–4.04).

The sensitivity analyses showed no modifications in the results after removing one article at a time.

Muscular fitness

Our meta-analysis shows that muscular strength has moderate track from childhood and/or adolescence to adulthood (r=0.51; 95% CI: 0.43–0.59; I^2=87.9%) (*Figure 2*), showing similar stability by sex (men: r=0.49, 95% CI: 0.42–0.57, I^2=53.8%; women: r=0.51, 95% CI: 0.39–0.62, I^2=77.5%), test used (leg extensors: r=0.57, 95% CI: 0.35–0.79, I^2=96.5%; bench press: r=0.46, 95% CI: 0.35–0.56, I^2=63.5%; handgrip: r=0.48, 95% CI: 0.41–0.56, I^2=74.5%; vertical jump: r=0.58, 95% CI: 0.36–0.80, I^2=96.1%), and age at baseline (childhood: r=0.46, 95% CI: 0.41–0.51, I^2=4.1%; adolescence: r=0.52, 95% CI: 0.42–0.61, I^2=89.6%).

The meta-regression analysis showed that the length of follow-up did not moderate this association (β =0.004; 95% CI: –0.006 to 0.015; P=0.414).

Minor asymmetry suggestive of small-study effects was observed (LKF index =–1.10).

The sensitivity analyses indicated no modifications in the results after removing 1 study at a time in muscular strength.

Muscular endurance has moderate track from youth to adulthood (r=0.50; 95% CI: 0.36–0.86; I^2=94.5%) (*Figure 2*), independent of sex (men: r=0.33, 95% CI: 0.20–0.47, I^2=55.4%; women: r=0.46, 95% CI: 0.32–0.60, I^2=28.6%).

Table 1 Studies that analyzed the tracking of fitness from childhood or adolescence to adulthood or mid-adulthood

Author and year	Sample size at follow-up (men/women)	Track period	Follow-up (period)	Physical fitness test
Andersen and Haraldsdóttir, 1994 (32)	168 (78/90)	Adolescence (16–19 years old) → adulthood (23–27 years old)	8 years (1983 to 1991)	Maximal cycloergometer
				Arm flexors
				Leg extensors
				Trunk flexors
				Trunk extensors
Barnekow-Bergkvist *et al.* 1996 (33)	278 (157/121)	Adolescence (16 years old) → adulthood (34 years old)	18 years (1974 to 1992)	Submaximal cycloergometer
				Arm flexors
				Curl-up
				Sit-ups
				Bench press
				Handgrip
				Two-hand lift
				Sargent jump
				Standing balance on one leg
Beunen *et al.* 1992 (22)	173 (173/0)	Adolescence (13 years old) → adulthood (30 years old)	17 years (1969 to 1986)	20-m shuttle test
				Leg lifts
				Bent arm hang
				Arm pull
				Vertical jump
				Sit and reach
Blasquez Shigaki *et al.* 2020 (31)	142 (71/71)	Childhood (9 years old) → young adulthood (21–25 years old)	15 years (2002 to 2016)	9-min run
				Sit-ups
				Sit and reach
Boreham *et al.* 2004 (27)	476 (245/231)	Adolescence (15 years old) → young adulthood (22 years old)	7 years (1990 to 1997)	20 m shuttle test
Campbell *et al.* 2001 (42)	153 (77/76)	Childhood and adolescence (8–18 years old) → young adulthood (20–30 years old)	12 years (1980 to 1992)	PWC_{150}
Cleland *et al.* 2009 (43)	645 (333/312)	Childhood and adolescence (7–15 years old) → adulthood (26–36 years old)	19.6 years (1985 to 2004-6)	PWC_{170}
Fraser *et al.* 2017 (41)	623 (322/301)	Childhood and adolescence (9–15 years old) → young adulthood (29–35 years old)	20 years (1985 to 2005)	Handgrip
				Shoulder flexion
				Shoulder extension
				Leg strength
				Standing long jump

Table 1 (*continued*)

Table 1 (*continued*)

Author and year	Sample size at follow-up (men/women)	Track period	Follow-up (period)	Physical fitness test
Fraser *et al.* 2021 (26)	Children: 385 (NR) Adolescents: 822 (NR)	Childhood and adolescence (9–15 years old) → mid-adulthood (36–49 years old)	32.5 years (1985 to 2014)	Handgrip Shoulder flexion Shoulder extension Leg strength
Hasselstrøm *et al.* 2002 (34)	168 (78/90)	Adolescence (15–19 years old) → young adulthood (23–28 years old)	8 years (1983 to 1991)	Maximal cycloergometer Isometric strength
Kemper *et al.* 1990 (35)	200 (93/107)	Adolescence (13 years old) → young adulthood (21 years old)	9 years (1977 to 1985)	Maximal cycloergometer
Kemper *et al.* 2001 (36)	365 (164/201)	Adolescence (13–17 years old) → adulthood (33 years old)	20 years (1977 to 1997)	12-min endurance run Leg lifts Bent arm hang Arm pull Vertical jump Sit and reach
Lefevre *et al.* 2000 (23)	130 (130/0)	Adolescence (13–18 years old) → adulthood (40 years old)	29 years (1969 to 1996)	Maximal cycloergometer Flamingo balance Vertical jump Sit-ups Handgrip Bent arm hang Sit and reach
Mäestu *et al.* 2020 (37)	492 (210/282)	Adolescence (15 years old) → young adulthood (33 years old)	18 years (1998 to 2016)	Maximal cycloergometer
Matton *et al.* 2006 (24)	138 (0/138)	Adolescence (14–18 years old) → adulthood (37–43 years old)	24 years (1979 to 2003)	50-m shuttle run Flamingo balance Arm pull Vertical jump Leg lifts Bent arm hang Sit and reach
Mikkelsson *et al.* 2006 (25)	45 (20/25)	Adolescence (9–21 years old) → adulthood (34–46 years old)	25 years (1976 to 2001)	Maximal treadmill Sit-ups Handgrip Sit and reach

Table 1 (*continued*)

Table 1 (*continued*)

Author and year	Sample size at follow-up (men/women)	Track period	Follow-up (period)	Physical fitness test
Sorić *et al.* 2014 (38)	50 (31/19)	Adolescence (15 years old) → mid-adulthood (36–43 years old)	22–27 years (1979 to 2006)	Maximal treadmill
Taeymans *et al.* 2009 (30)	119 (59/60)	Childhood (6–18 years old) → mid-adulthood (35 years old)	30 years (1986 to 2004)	Handgrip Sit-ups
Trudeau *et al.* 2003 (29)	153 (96/57)	Childhood (10–12 years old) → young adulthood (35 years old)	25 years (1970 to 1996)	PWC_{170} Sit-ups Handgrip
Twisk *et al.* 1997 (39)	181 (83/98)	Adolescence (13 years old) → young adulthood (27 years old)	14 years (1977 to 1991)	Maximal treadmill
Van Oort *et al.* 2013 (28)	78 (59/18)	Childhood and adolescence (7–17 years old) → mid-adulthood (40–50 years old)	45 years (1965 to 2010)	Maximal treadmill
Westerståhl *et al.* 2018 (40)	213 (114/99)	Adolescence (16 years old) → mid-adulthood (52 years old)	36 years (1974 to 2010)	9-min run Two-hand lift Bench press Curl-up Handgrip

PWC_{170}, physical work capacity at a heart rate of 150 beats per minute; NR, not reported.

Considering the test used, the sit-ups test shows moderate stability (r=0.42; 95% CI: 0.26–0.59; I^2=84.5%) and the bent arm hang shows high stability (r=0.67; 95% CI: 0.52–0.82; I^2=94.1%). Regarding age at baseline, tracking studies from adolescence show a higher correlation coefficient but also moderate (r=0.56; 95% CI: 0.41–0.71; I^2=94.2%).

The meta-regression analysis indicated that the length of follow-up did not moderate this association (β =–0.008; 95% CI: –0.006 to 0.015; P=0.414).

Major asymmetry suggestive of small-study effects was observed (LKF index =–7.01).

The sensitivity analyses showed no modifications in the results after removing one article at a time.

Flexibility

The tracking for flexibility from childhood and/or adolescence to adulthood was high (r=0.69; 95% CI: 0.58–0.81; I^2=92.9%) (*Figure 2*), with similar correlation coefficient in men and without inconsistency (r=0.68; 95% CI: 0.61–0.74; I^2=0%) and from adolescence (r=0.71; 95% CI: 0.57–0.85; I^2=94.4%). Regarding women, only two studies included this fitness component and therefore, no pooled data was analyzed.

The meta-regression analysis showed that the length of follow-up moderates this association, showing higher correlation coefficients with larger follow-up (β =0.017; 95% CI; 0.012–0.021; P<0.001) (*Figure 3*).

Major asymmetry suggestive of small-study effects was observed (LKF index =–3.89).

The sensitivity analyses showed no modifications in the results after removing one article at a time.

Discussion

Our study describes the extent of tracking for a range of physical fitness components, from childhood and/or adolescence to adulthood in 3,260 men and 2,937 women from 21 prospective studies. Findings suggest that cardiorespiratory fitness, muscular strength, and muscular endurance have moderate stability from childhood and/ or adolescence to adulthood, independent of test used. This moderate tracking was slightly higher in women than

Table 2 Items of Quality Assessment Tool for Observational Cohort and Cross-sectional Studies

Author, year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total score
Andersen and Haraldsdóttir, 1994 (32)	NR	√	√	√	NR	√	√	√	√	×	√	×	×	NR	8
Barnekow-Bergkvist *et al.* 1996 (33)	√	√	NR	√	NR	√	√	√	√	×	√	×	×	NR	8
Beunen *et al.* 1992 (22)	√	√	√	√	NR	√	√	√	√	×	√	×	×	NR	9
Blasquez Shigaki *et al.* 2020 (31)	√	√	√	√	NR	√	√	√	√	×	√	×	×	NR	9
Boreham *et al.* 2004 (27)	√	√	√	√	NR	√	√	√	√	×	√	×	×	NR	9
Campbell *et al.* 2001 (42)	√	√	NR	√	NR	√	√	√	√	×	√	×	√	NR	9
Cleland *et al.* 2009 (43)	√	√	√	√	NR	√	√	√	√	×	√	×	×	NR	9
Fraser *et al.* 2017 (41)	√	√	×	√	NR	√	√	√	√	×	√	×	×	NR	8
Fraser *et al.* 2021 (26)	√	√	NR	√	NR	√	√	√	√	×	√	×	NR	NR	8
Hasselstrøm *et al.* 2002 (34)	√	√	√	√	NR	√	√	√	√	×	√	×	√	NR	10
Kemper *et al.* 1990 (35)	√	√	NR	√	NR	√	√	√	√	√	√	×	×	NR	9
Kemper *et al.* 2001 (36)	√	√	NR	√	NR	√	√	√	√	√	√	×	×	NR	9
Lefevre *et al.* 2000 (23)	√	√	NR	√	NR	√	√	√	√	√	√	×	×	NR	9
Mäestu *et al.* 2020 (37)	√	√	√	√	NR	√	√	√	√	√	√	×	√	NR	11
Matton *et al.* 2006 (24)	√	√	NR	√	NR	√	√	√	√	×	√	×	×	NR	8
Mikkelsson *et al.* 2006 (25)	√	√	√	√	NR	√	√	√	√	×	√	×	×	NR	9
Sorić *et al.* 2014 (38)	√	√	NR	√	NR	√	√	√	√	√	√	×	×	NR	9
Taeymans *et al.* 2009 (30)	√	√	NR	√	NR	√	√	√	√	×	√	×	×	NR	8
Trudeau *et al.* 2003 (29)	√	√	×	√	NR	√	√	√	√	×	√	×	NR	NR	8
Twisk *et al.* 1997 (39)	√	√	NR	√	NR	√	√	√	√	×	√	×	√	NR	9
Van Oort *et al.* 2013 (28)	√	√	NR	√	NR	√	√	√	√	√	√	×	×	NR	9
Westerståhl *et al.* 2018 (40)	√	√	NR	√	NR	√	√	√	√	×	√	×	×	NR	8

√, yes; ×, no. NR, not reported.

in men and from adolescence compared to childhood. The stability was also higher in the flexibility component. Therefore, these findings could promote childhood and adolescence physical fitness as a screening tool to help identify youths at high risk of maintaining unfavourable levels of fitness into adulthood. Once high-risk children or adolescents are recognized, their fitness trajectories could and should be improved.

Scientific literature assumed that physical fitness levels during childhood and adolescence is beneficial for health during adulthood. For example, some previous longitudinal studies from a nationwide cohort of one million Swedish men who were examined at 18 years of age suggested that low cardiorespiratory fitness (estimated by a maximal cycloergometer test) and muscular fitness (assessed by knee extension and handgrip tests) were associated with an increased risk of type 2 diabetes (44), myocardial infarction (45), and premature mortality (46) during adulthood. It assumes that children and adolescent physical fitness may have an indirect influence on adult health status by increasing the likelihood of becoming an active adult and have good fitness, which in turn could be beneficial for adult health. Blair *et al.* (47) also established other two conceptual pathways to explain relationships between physical fitness during childhood and/or adolescence and health during adulthood: through its effect on children and adults health or directly. In this sense, the current study found that both cardiorespiratory fitness and muscular fitness (i.e., muscular strength and endurance) tracking moderate from childhood and/or adolescence to adulthood and high stability for

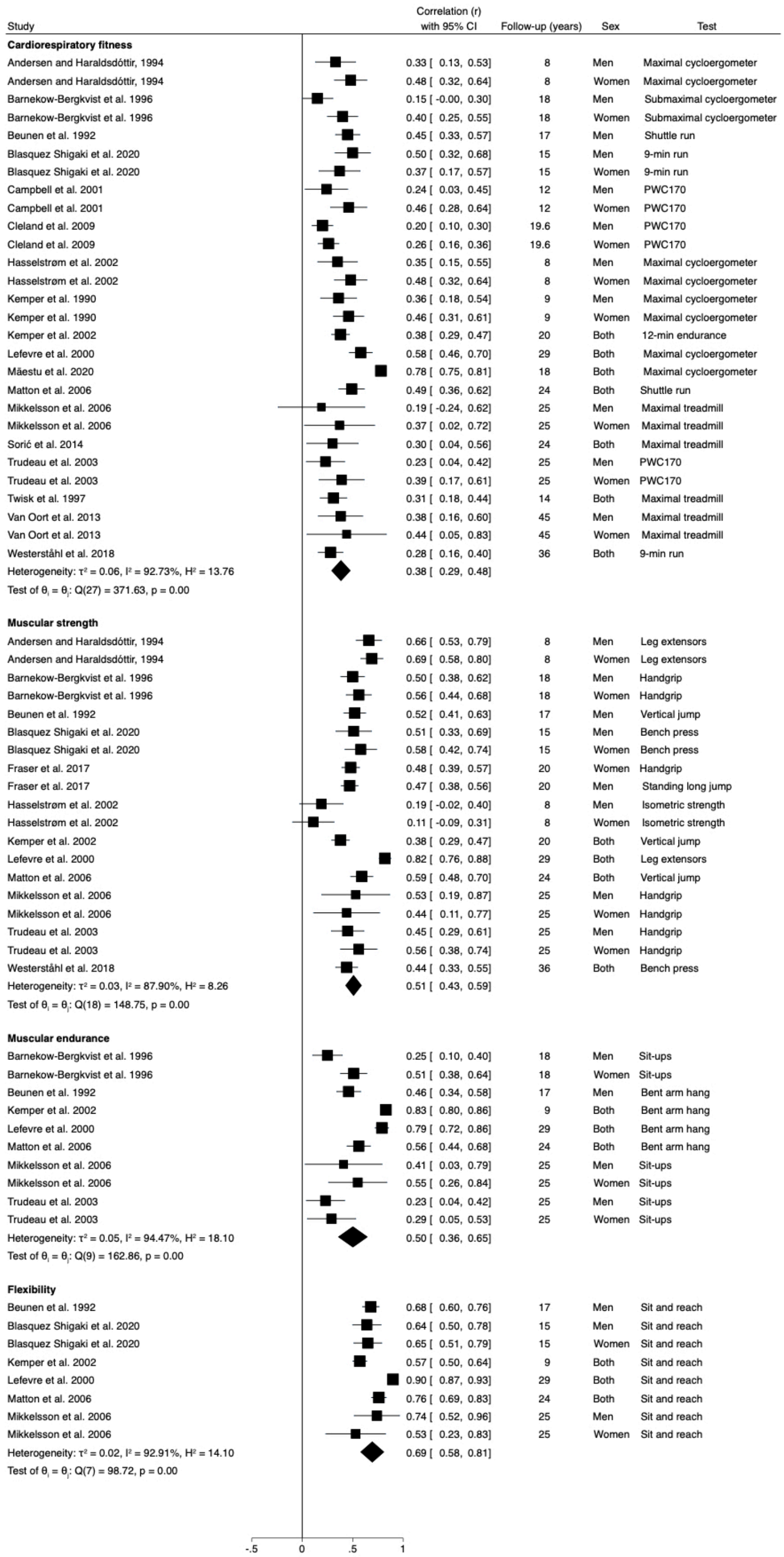

Figure 2 Pooled estimated correlation coefficients for fitness tracking from youth to adulthood. PWC_{170}, physical work capacity at a heart rate of 150 beats per minute.

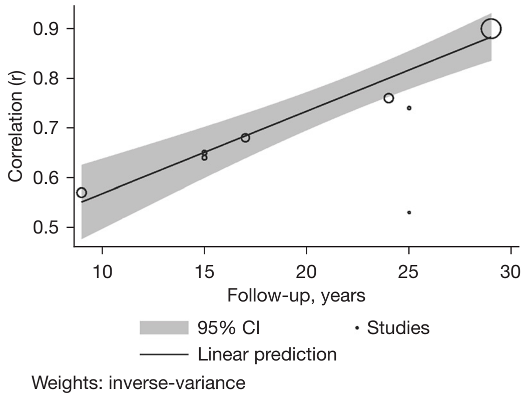

Figure 3 Associations of length of follow-up (years) with correlation coefficients of flexibility tracking from youth to adulthood. The solid line indicates a linear relationship. The size of each data point is proportional to its statistical weight.

flexibility. Therefore, physical capacity seems to be fairly stable, which could be related with fewer health problems as discussed above (3,44-46).

It is interesting to note that the stability of cardiorespiratory fitness is slightly less stable than that of other fitness components. A possible explanation for this finding may be likely a result of the inconsistency of adults to maintain the numerous factors that are known to influence cardiorespiratory fitness (48). We could also speculate that while much activity during young is organized (e.g., school based, sports clubs), by the time the individual reaches early adulthood, practice physical activity is likely to be more a matter of choice (27). It was also suggested that tracking of cardiorespiratory fitness diminishes as the measurement length of follow-up increases (28). This would suggest that youth' cardiorespiratory fitness is more readily maintained over shorter time intervals and their levels could greatly fluctuate with increased length of follow-up. Otherwise, our meta-regression analyses reported that length of follow-up did not moderate the tracking correlation coefficients, except in the flexibility component.

Regarding muscular fitness, we found that levels of muscular strength and endurance remain relatively moderate stable from childhood or adolescence to adulthood or mid-adulthood. For example, Fraser *et al.* reported in Australian children and adolescents that those with lower muscular fitness levels had an increased risk of remaining in the same level in adulthood (41) and mid-adulthood (26). These findings highlight young as a potentially key period to promote increased muscular strength and endurance to help encourage favourable levels and healthiest profile into adulthood (5). Another important consideration is that stability seems to be slightly stronger from adolescent than from childhood. A possible explanation for this might be due to a more stable fat free mass and body mass that coincides with later stage puberty compared with pre- and peri-pubertal youth (22,24). Also, women show slightly stronger stability than men, especially in muscular endurance, which may be due to the earlier adrenal androgen production and the higher oestrogen concentration leading to an earlier deceleration of somatic growth in women (49).

The sit and reach test, an indicator of flexibility, showed the highest tracking coefficients from childhood and/or adolescence to adulthood. Blasquez Shigaki *et al.* (31) corroborate this finding showing high stability with an intraclass correlation coefficient of 0.64 and 0.65 in men and women, respectively. This may be partly explained by genetic factors (25). Contrary to expectations, meta-regression analysis shows stronger stability as years of follow-up increase. Malina (7) corroborated that correlations with flexibility at 30 years tend to increase with age as children progress through adolescence, which could explain our findings.

It is important to bear in mind that children and adolescent differences in the timing and tempo of the growth spurt and sexual maturity may have implications for physical fitness during adulthood. Taeymans *et al.* (30) showed that adult handgrip strength predictability is low in early maturing boys and late maturing girls. Also, late maturing boys tend to have a favorable strength-to-weight ratio in childhood and at age 35, showing lower and more stable ratio in all girls groups. In contrast, Beunen *et al.* (22) show that an advanced biological maturation was related to lower adults' performance for the arm pull and vertical jump tests. This finding is consistent with that of Lefevre *et al.* (23) who suggest that performance advantage of the early maturing boys assessed during adolescence revers to a disadvantage or disappear at 30 years old.

The generalisability of these results is subject to certain limitations. First, correlations coefficients simply show an association between the past and the present, and therefore, do not predict the future and do not establish a cause-effect order (7). Second, interage age correlations coefficients need to be viewed in the context of healthy lifestyle changes over the past generations. For example, lifestyle changes over the past two generations include reduced levels of physical activity (50) (e.g., reduced active commuting to school) and fitness (51), increased screen time (52), among others. It seems possible that these changes could explain large heterogeneity between studies and correlation coefficients, since several studies carried out its follow-up assessment before year 2000 (22,23,27,29,34,36-40,42) and others after 2000 (24-26,28,30-33,35,41,43). Finally, differences in the type of tests, length of follow-up, age at baseline, and different statistical models taken could also explain heterogeneity and inconsistency between correlation coefficients.

Conclusions

This study has shown that physical fitness is fairly stable from childhood and/or adolescence to adulthood. Given that low levels of cardiorespiratory and muscular fitness in adulthood are related with several chronic diseases, intervention programs for physical fitness training should be planned early. Therefore, our data warrant further research into whether early intervention designed at modifying low youth physical fitness levels could potentially reduce these future chronic diseases (3).

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Footnote

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