

Regression of physical fitness in pre-adolescent: is it a real trend?

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Abstract

Problem Statement: A decline in fitness capacities (cardiovascular, muscle strength, speed-agility and power) was reported in multiple studies of the last decades. Further, in support of this hypothesis, literature suggested that the increase of sedentary lifestyle, the use of electronic devices and other factor, such as industrialization, negatively influenced the fitness over the time in children and adolescent. **Approach:** 280 pre-adolescents of both gender (between 13- and 14-year-old) attending the first year of middle school course in northern Italy were assessed from 2005 to 2011. Four physical fitness components were evaluated using field tests of the Eurofit test battery (sit and reach test (SAR), standing broad jump (SBJ), 12min run test, 30m sprint test). **Purpose:** The purpose of the study was to evaluate the trend in the physical fitness of Italian adolescents across six years. **Results:** Our results suggested a difference from 2005 to 2011 in both genders. In SAR, there were decreases only for boys ($p=0.025$). SBJ performance decreased in both genders but significantly only for girls ($p<0.001$). Also, 12min run test performance showed a decrease in both gender ($p<0.001$). Finally, 30m Sprint speed-agility decreased in girls ($p<0.001$) while boys had an inverse trend. **Conclusions:** Overall, the results of this study showed a slight decline of the physical fitness, and in some cases, not even significant (SBJ, SAR, 30m sprint). In authors opinion, excessive alarmism was created about the regression of motor fitness performance in the developmental age.

Keyword: Physical Fitness, Adolescent, Eurofit, Longitudinal, Sedentary

Introduction

Worldwide sedentary lifestyle is rising especially in children (Przeweda et al., 2003) where electronic devices (television, video games, tablet, smartphone) is usually preferred to physical activity (PA). The increasing use of motorized transports (car, bus, scooter) instead of human locomotion (bicycles, feet, longboard, roller) further aggravates the situation (Carlson et al., 2014). Public opinion is concerned about this alarming situation and for the regression of motor skills in the developmental age, mainly caused by the decrease of PA in industrialized countries (Dunnet et al., 2000; Giuriato et al. 2021). From pre-school age the combination of these behaviors negatively affects people lifestyle (Wydra, 2004). Extreme urbanization drove to a cut of parks and green areas reducing possibilities to practice PA daily and outdoor activities (Valentine et al., 1997; Foster et al., 2014). In general, the PA practice was found to be influenced by various factors such as the socio-economic status (Freitas et al., 2007;), the urban/rural context (Lovecchio et al., 2015), the availability of facilities (Malina et al., 2007;), the cultural habits and the educational level of parents (Tomkinson et al., 2007). Furthermore, the loss of spontaneous motion seems to be the leading cause of the decrease in biological energy expenditure contributing to a dramatic increase in prevalence of overweight and obesity during childhood (Arpesella et al. 2008; Carnevale Pellino et al. 2020; Eisenmann, 2006; Vandoni et al. 2021a; Vandoni et al. 2021b;) and a decrease of the centuries-old trends of motor skills and physical efficiency (physical fitness, Tomkinson et al., 2007). In fact, some studies showed a drop in the conditional performance of children over the years in cardiovascular endurance, power, muscle strength and speed-agility (Tomkinson et al., 2007; Matton et al., 2007). Among the most significant studies; Tomkinson et al. (2007) included a large dataset from 27 countries founding a reduction in aerobic capacity in the developmental age (from 6 to 19 years) over 45 years (1958-2003). The same decline was highlighted in other motor skills (power, muscle strength and speed-agility) on children and adolescents from Northern European countries (Matton et al., 2007).

Thus, the present study aimed to verify the existence of a regression in motor skills over ten years (2005-2011) in an Italian student population. The authors believe that the decline in physical fitness (measured in generic terms) has not changed significantly.

Materials and methods

The temporal study was conducted from 2005 to 2011 and involved about 280 pre-adolescents of both genders (age range, 13-14year-old) attending the first years of high school course in a small town of northern Italy. The numerosity of the sample per age, sex, and test is showed in Table 1.

Table 1. Numerosity for each test between years (2005 – 2011) and gender (boys, girls)

Abbreviation: SBJ= Standing Broad Jump, SAR= Sit and Reach, 30m= 30m sprint test, b= boys, g= girls

Year	SBJ		SAR		12min Run test		30 m	
	b	g	b	g	b	g	b	g
2005	31	34	31	37	32	34	32	36
2006	29	34	29	33	27	32	29	34
2007	30	36	31	34	29	33	31	33
2008	40	30	37	30	38	30	39	29
2009	45	31	45	32	44	30	43	31
2010	38	30	38	32	37	32	38	30
2011	34	30	35	35	34	33	34	29

Inclusion criteria were physical fitness certificate and regular physical education class attendance. Teachers and students received written information about the study purpose and procedure. Each feature of the experimental design, was approved by the ethical boards of the enrolled schools in accordance with the World Medical Association Declaration of Helsinki, as revised in 2018. Written informed consent was obtained from the parents or legal guardians, while verbal assent was obtained from the children after the explanation of the general study purposes. All the participants were free to withdraw their participation at any time while no extra academic credits were awarded for their inclusion in the study.

Procedure

The tests were conducted by the curricular physical education (PE) teacher of during school time with the compliance of the student (Berkson et al., 2013). All the tests were administered during the first-year of the high school at the beginning of each school year (September). Year-by-year data collection was conducted by Sport Science University students supervised by a researcher ensuring the accuracy and repeatability of test procedures (Kemper et al., 1996).

Physical fitness evaluation

Four physical fitness components were evaluated using field tests from the Eurofit test battery (Council of Europe, 1988), as administered in similar previous studies (Giuriato et al., 2021; Lovecchio et al., 2019). All the four tests are reliable, valid instruments to measure physical fitness (Kemper et al., 1996) and are considered independent of each other. A brief explanation is given below:

Sit and Reach (SAR): Students sit on the ground with the soles of their feet against a box (Sit and Reach box) above which a meter is placed. Subjects had to flex their torso forward, extend their hands over the box as far ahead as possible, and hold the position for two seconds (measurement time). The knees must not lift off the ground, the fingers of both hands must reach the same distance, and no movements are allowed. Tests were performed three times and the best performance (in centimeters) was considered.

Standing Broad Jump (SBJ): Each subject performed a long jump starting from a standing position, with the knees slightly bent. The subject had to swing their arms, push themselves strongly forward and jump as far as possible. The landing had to take place in an upright position and with the feet parallel. Measurement was taken from the take-off point (tip of the foot) to the rearmost point of the body during landing (heel) and is expressed in centimeters. After carrying out three tests, the best result was considered.

12min Run Test (12minRT): The subjects were instructed to run along the path delimited by the cones to do the greater number of laps in 12 minutes. At the end of the test, the total laps run by each student were recorded and multiplied by the length of the path, obtaining the total distance covered (in meters) in 12 minutes.

30m sprint test (30mST): The subjects, starting from standstill position, had to run the distance of 30 meters (delimited with cones at the start and finish line) as fast as possible. The measurement (in seconds) was

recorded with a stopwatch by the teacher. Three tests had to be performed, always with a complete recovery, and only the best one was considered.

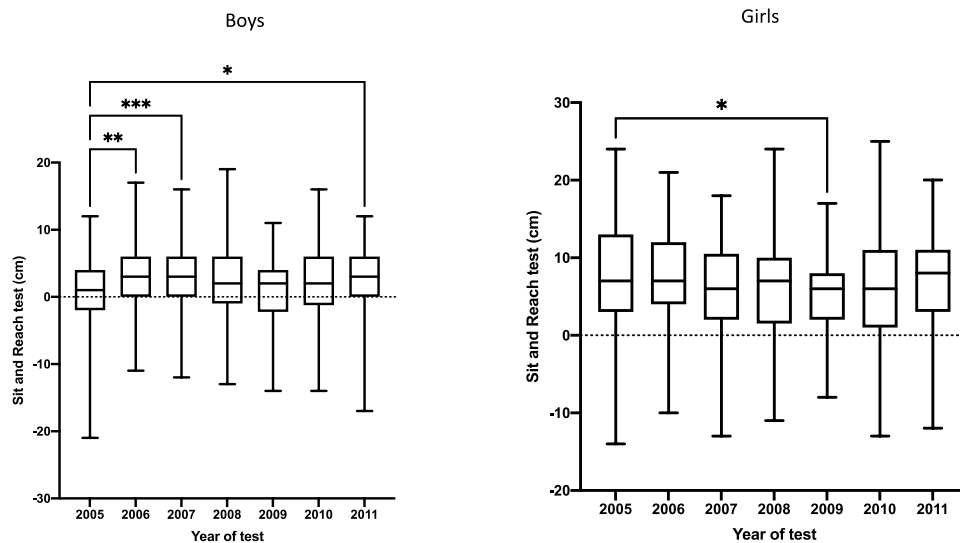
Statistical analysis

All the data were manually entered into a spreadsheet and checked for transcription errors, with corrections made where appropriate with Microsoft Excel. The dataset was also suspended for outliers. Descriptive statistics were provided as mean $\pm$ standard deviations (SD). Further, the Kruskal-Wallis test was run to verify the existence of a variation in the performance of the subjects in the conditional tests during the decade 2005- 2011. We calculated the difference between the test years using a One-way ANOVA for every single test and sex. The significance was set at 0.05.

Results

Our results showed a statistical difference from 2005 with 2011 in both genders. In SAR, there were significant differences from 2005 to 2011, only for boys ($p=0.025$) and not for girls ($p>0.999$) (Figure 1). Figure 1. Sit and Reach test performance along the years (2005 – 2011).

Note. Boys: * $p=0.0252$; ** $p=0.0086$; *** $p=0.0001$; Girls: * $p=0.0473$

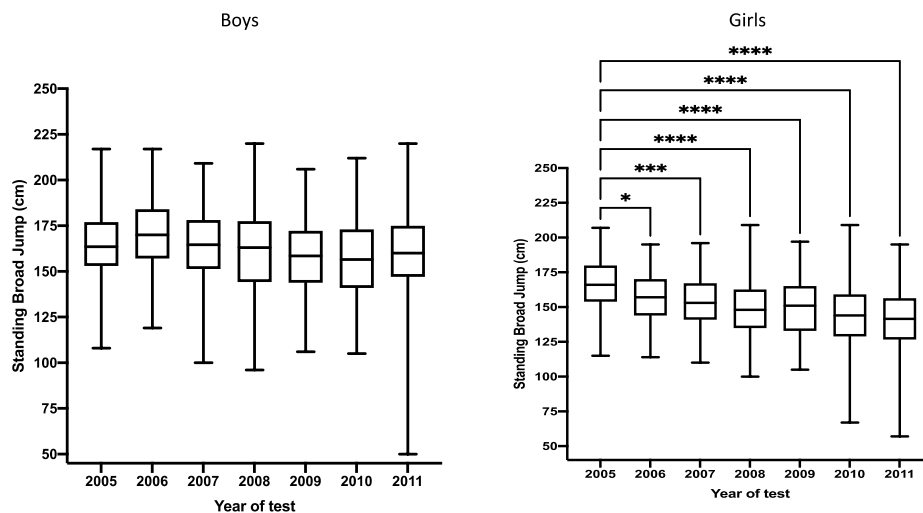


A lack of homogeneity in SD test was observed between the subjects. Moreover, boys' flexibility increased (2005: 0.65cm $\pm$ 4.81; 2011: 2.13cm $\pm$ 5.28), while in girls decreased (2005: 7.46cm $\pm$ 7.43; 2011: 6.80cm $\pm$ 6.01).

SBJ performance decreased in both genders (Boys= 2005: 163.88cm $\pm$ 19.71; 2011: 159.93cm $\pm$ 22.73, $p>0.999$; Girls= 2005: 165.63cm $\pm$ 18.24; 2011: 141.05cm $\pm$ 23.89, $p<0.001$) (Figure 2)

Figure 2. Standing Broad Jump test performance along the years (2005 – 2011).

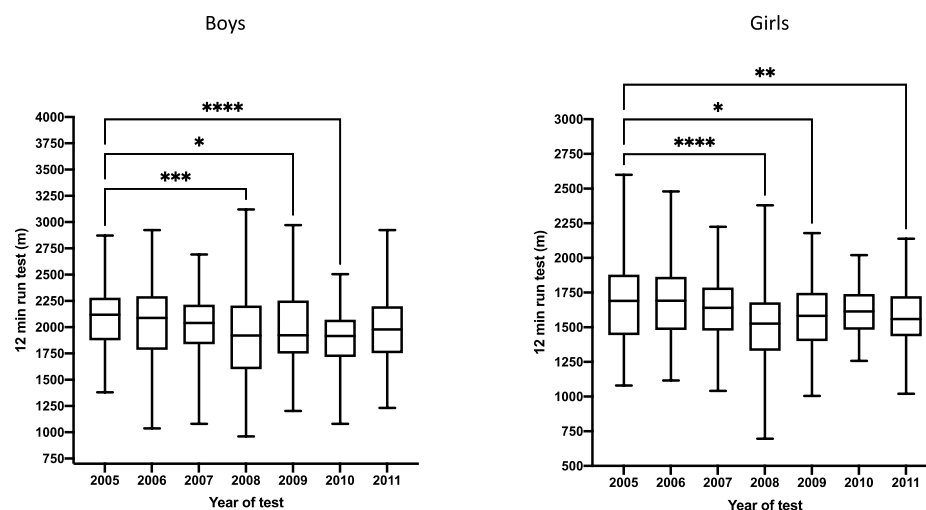
Note. Girls: * $p=0.0135$; *** $p=0.0003$; **** $p<0.0001$



Further, 12min run test performance showed a significant decrease in both genders (Boys= 2005: 2014.99m $\pm$ 348.93; 2011: 1979.52m $\pm$ 316.50, Girls= 2005: 1701.17m $\pm$ 302.17; 2011: 1572.89cm $\pm$ 218.99, Particularly, a significant difference was found in boys between 2005 and 2008 ($p<0.001$); and 2010 ($p<0.001$) and in girls between 2005 and 2008 ($p<0.001$); 2009 ($p=0.0137$); and 2011 ($p=0.003$) (Figure 3).

Figure 3. 12 min run test performance along the years (2005 – 2011).

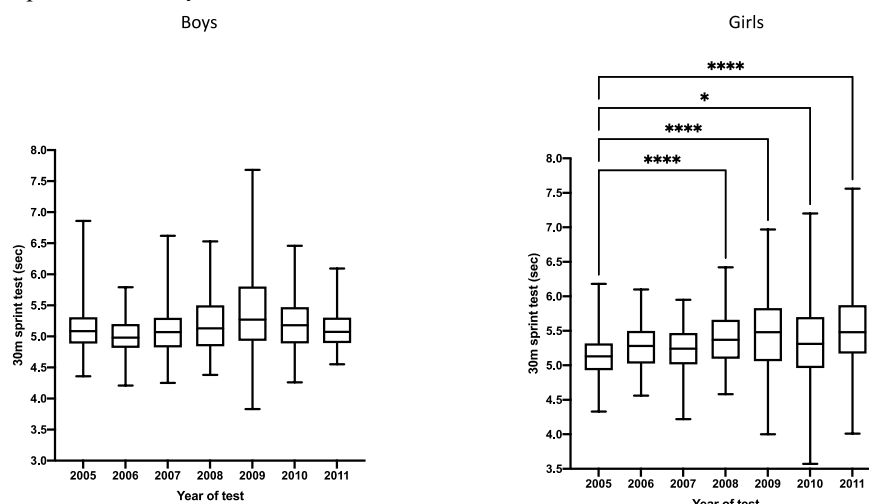
Note. Boys: * $p=0.0283$; *** $p=0.0002$; **** $p<0.0001$; Girls: * $p=0.0137$; ** $p=0.0031$; **** $p<0.0001$



Finally, 30m Sprint speed-agility decreased in girls (2005: 5.15s $\pm$ 0.34; 2011: 5.52 $\pm$ 0.58, $p<0.001$) particularly between 2005 and 2008 ($p<0.001$), 2009 ($p<0.001$), 2010 ($p=0.018$), and 2011 ($p<0.001$) while boys had an inverse trend (2005: 5.15s $\pm$ 0.43; 2011: 5.09s $\pm$ 0.31), (Figure 4).

Figure 4. Sprint test (30m) performance along the years (2005 – 2011).

Note. Girls: * $p=0.0182$; **** $p<0.0001$



Discussion

The results of this study are partially in line with Tomkinson et al. (2007) that indicate a decline in aerobic and other conditional capacities such as muscle strength, speed-agility and power. However, our results suggested a slight decline, and in some cases, not even significant (SBJ, SAR, 30m sprint) (Figure 1 – 4). Contrariwise, Moliner-Urdiales et al. (2010) found that Spanish adolescents in 2006-2007 improved the performance in similar cardiovascular endurance tests (20m shuttle Run) and speed agility (4 $\times$ 10m Shuttle Run) compared to their peers of five years before (2001-2002). Further, Andersen et al. (2009) showed a steady state in aerobic performance from 1983 to 2003 in Danish children and adolescents. The performance in speed ability of Lithuanian children and adolescents was in line with our results, suggesting an improvement in boys' speed shuttle run test (comparable to our 30m Sprint Test) between 1992 and 2002. On the other hand, our results showed a decrease in performance in girls. Indeed, no substantial changes in Lithuanian performance were reported (Venckunas et al., 2017). Kemper et al. (1996) showed that essential changes in SBJ did not appear in 11-year-old children performance from 2004 to 2013. Even Cohen et al. (2011) reported an increase in the SBJ performance of 11-year-old English students from 1998 to 2008. The English study showed a positive variation

in SBJ performance of 0.43% for boys and 0.71% for girls ($p < 0.001$). Conversely, our results reported a decrease for both genders, with a decrement of 3.7% and 17% for boys and girls.

Conclusion

As mentioned, the level of PA is influenced by multiple factors such as economic development, socio-economic status, urban/ rural context, the availability of facilities, cultural habits, and the level of education of parents (Freitas et al., 2007; Malina et al., 2007; Carlson et al., 2014). We observed a slight decline in the fitness level performances compared to other European country probably because our sample could had a rural origin (Tsimeas et al., 2005).

The small sample recruited for our study could be considered a limit. However, children performance aligns with one recent research by Lovecchio et al. (2019) with a larger sample. 31.476 students (aged from 11 to 13-year-old) from six European countries were tested through the Eurofit test battery to obtain predictive values of European adolescents fitness level (Lovecchio et al., 2019). This research revealed that in the SBJ test, the European average of 11-year-old males was 154 cm, 5cm less than the boys of our study in 2011. In the same test, European girls reached an average of 142cm, 1cm more than our girls in 2011. Even in the SAR test, the performance is similar: European females reached 4.5 cm of flexibility, only 0.7cm less than our girls (5.28cm). Further, boys performed a value of -0.25 cm in the European sample, which slightly differs from our value (0.65cm). It is, therefore, evident that the fitness performance tested in this study children slightly regressed. However, the fitness decline can be considered in line with the performance of a much larger European sample previously analyzed (Lovecchio et al. 2019). In authors opinion, excessive alarmism was created about the regression of motor fitness performance in the developmental age.

References

- 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), 757–763. <https://doi.org/10.1111/j.1600-0838.2009.00936.x>
- Arpesella, M., Camprostrini, S., Gerzeli, S., Lottaroli, S., Pane, A., Traverso, M. A., ... & Coppola, L. (2012). Obesity nutritional aspects and life style from a survey on a sample of primary school pupils in the Pavia province (Northern Italy). *Italian Journal of Public Health*, 5(1). DOI: 10.2427/5849
- Berkson, S. S., Espinola, J., Corso, K. A., Cabral, H., McGowan, R., & Chomitz, V. R. (2013). Reliability of height and weight measurements collected by physical education teachers for a school-based body mass index surveillance and screening system. *The Journal of school health*, 83(1), 21–27. <https://doi.org/10.1111/j.1746-1561.2012.00743.x>
- Carnevale Pellino, V.; Giuriato, M.; Ceccarelli, G.; Codella, R.; Vandoni, M.; Lovecchio, N.; Nevill, A.M. Explosive Strength Modeling in Children: Trends According to Growth and Prediction Equation. *Appl. Sci.* 2020, 10, 6430. <https://doi.org/10.3390/app10186430>
- Carlson, J. A., Sallis, J. F., Kerr, J., Conway, T. L., Cain, K., Frank, L. D., & Saelens, B. E. (2014). Built environment characteristics and parent active transportation are associated with active travel to school in youth age 12-15. *British journal of sports medicine*, 48(22), 1634–1639. <https://doi.org/10.1136/bjsports-2013-093101>
- Cohen, D. D., Voss, C., Taylor, M. J., Delextrat, A., Ogunleye, A. A., & Sandercock, G. R. (2011). Ten-year secular changes in muscular fitness in English children. *Acta paediatrica (Oslo, Norway : 1992)*, 100(10), e175–e177. <https://doi.org/10.1111/j.1651-2227.2011.02318.x>
- Council of Europe (1988). Eurofit: Handbook for the Eurofit Tests of Physical Fitness. Rome (IT): Council of Europe.
- Dunnett, N., Swanwick, C., & Woolley, E. (2002). Improving Urban Parks, Play Areas and Green Spaces, Department of Landscape, University of Sheffield DTLG, London, May.
- Eisenmann J.C. (2006) Insight into the causes of the recent secular trend in pediatric obesity: common sense does not always prevail for complex, multifactorial phenotypes. *Preventive Medicine* 42: 329-335
- Foster, S., Villanueva, K., Wood, L., Christian, H., & Giles-Corti, B. (2014). The impact of parents' fear of strangers and perceptions of informal social control on children's independent mobility. *Health & place*, 26, 60–68. <https://doi.org/10.1016/j.healthplace.2013.11.006>
- Freitas, D., Maia, J., Beunen, G., Claessens, A., Thomis, M., Marques, A., Crespo, M., & Lefevre, J. (2007). Socio-economic status, growth, physical activity and fitness: the Madeira Growth Study. *Annals of human biology*, 34(1), 107–122. <https://doi.org/10.1080/03014460601080983>
- Giuriato, M., Kawczynski, A., Mroczek, D., Lovecchio, N., & Nevill, A. (2021). Allometric association between physical fitness test results, body size/shape, biological maturity, and time spent playing sports in adolescents. *PloS one*, 16(4), e0249626. <https://doi.org/10.1371/journal.pone.0249626>
- Giuriato M, Codella R, Lovecchio N, Carnevale Pellino V, Vandoni M, Nevill AM. Speed agility trends in children according to growth. *Ann Hum Biol.* 2021 Jun;48(4):271-279. doi: 10.1080/03014460.2021.1928285. Epub 2021 Jul 19. PMID: 33974454.

- Kemper, H. C., & van Mechelen W (1996). Physical fitness testing of children: a European perspective. *Ped Exer Sci.* 1996; 8:201–14.
- 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), 1389–1396. <https://doi.org/10.23736/S0022-4707.18.08926-0>
- Lovecchio, N., Novak, D., Eid, L., Casolo, F., & Podnar, H. (2015). Urban and rural fitness level: comparison between Italian and Croatian students. *Perceptual and motor skills*, 120(2), 367–380. <https://doi.org/10.2466/06.PMS.120v11x8>
- Malina, R. M., & Little, B. B. (2008). Physical activity: the present in the context of the past. *American journal of human biology : the official journal of the Human Biology Council*, 20(4), 373–391. <https://doi.org/10.1002/ajhb.20772>
- Matton, L., Duvinéaud, N., Wijndaele, K., Philippaerts, R., Duquet, W., Beunen, G., Claessens, A. L., Thomis, M., & 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 : the official journal of the Human Biology Council*, 19(3), 345–357. <https://doi.org/10.1002/ajhb.20592>
- Moliner-Urdiales, D., Ruiz, J. R., Ortega, F. B., Jiménez-Pavón, D., Vicente-Rodriguez, G., Rey-López, J. P., Martínez-Gómez, D., Casajús, J. A., Mesana, M. I., Marcos, A., Noriega-Borge, M. J., Sjöström, M., Castillo, M. J., Moreno, L. A., & AVENA and HELENA Study Groups (2010). Secular trends in health-related physical fitness in Spanish adolescents: the AVENA and HELENA studies. *Journal of science and medicine in sport*, 13(6), 584–588. <https://doi.org/10.1016/j.jsams.2010.03.004>
- Przeweda, R., & Dobosz, J. (2003). Growth and physical fitness of Polish youths in two successive decades. *The Journal of sports medicine and physical fitness*, 43(4), 465–474.
- Tomkinson, G. R., Olds, T. S., & Borms, J. (2007). Who are the Eurofittest?. *Medicine and sport science*, 50, 104–128. <https://doi.org/10.1159/000101355>
- Tsimeas, P. D., Tsiokanos, A. L., Koutedakis, Y., Tsigilis, N., & Kellis, S. (2005). Does living in urban or rural settings affect aspects of physical fitness in children? An allometric approach. *British journal of sports medicine*, 39(9), 671–674. <https://doi.org/10.1136/bjmsm.2004.017384>
- Valentine, G., & McKendrick, J. (1997). Children's outdoor play: Exploring parental concerns about children's safety and the changing nature of childhood; *Geoforum*; vol 28; 2:219-235.
- Vandoni M, Calcaterra V, Carnevale Pellino V, De Silvestri A, Marin L, Zuccotti GV, Tranfaglia V, Giuriato M, Codella R, Lovecchio N. "Fitness and Fatness" in Children and Adolescents: An Italian Cross-Sectional Study. *Children (Basel)*. 2021 Aug 31;8(9):762. doi: 10.3390/children8090762. PMID: 34572192; PMCID: PMC8470229.
- Vandoni, M.; Lovecchio, N.; Carnevale Pellino, V.; Codella, R.; Fabiano, V.; Rossi, V.; Zuccotti, G.V.; Calcaterra, V. Self-Reported Physical Fitness in Children and Adolescents with Obesity: A Cross-Sectional Analysis on the Level of Alignment with Multiple Adiposity Indexes. *Children* 2021, 8, 476. <https://doi.org/10.3390/children8060476>
- Venckunas, T., Emeljanovas, A., Mieziene, B., & Volbekiene, V. (2017). Secular trends in physical fitness and body size in Lithuanian children and adolescents between 1992 and 2012. *Journal of epidemiology and community health*, 71(2), 181–187. <https://doi.org/10.1136/jech-2016-207307>
- Wydra G. Das Prinzip Anstrengung im Sportunterricht; in E. Christmann, E. Emrich & J. Flatau (Hrsg.), *Schule und Sport*. (2004) *Berichtsband zum Schulsportkongress des Landes-sportverbandes für das Saarland*; vol 17:107-122). Schorndorf: Hofmann.