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ORIGINAL

HEART RATE MEASUREMENT THROUGH CAROTID PULSE BY PRIMARY SCHOOL CHILDREN

MEDICIÓN DE LA FRECUENCIA CARDÍACA MEDIANTE PULSO CAROTÍDEO POR NIÑOS DE PRIMARIA

Sánchez-Lastra, M.A.[1], Diz, J.C.[2], Varela, S.[3], Ayán, C.[4]

[1] Postdoctoral researcher, Universidade de Vigo, Departamento de Didácticas Especiais, Facultade de Ciencias da Educación e do Deporte, 36310 Vigo (Spain) misanchez@uvigo.es
[2] Full professor, Universidade de Vigo, Departamento de Bioloxía Funcional e Ciencias da Saúde, Facultade de Ciencias da Educación e do Deporte, 36310 Vigo (Spain) jcdiz@uvigo.es
[3] Asistant professor, Universidade de Vigo, Departamento de Departamento de Didácticas Especiais, Facultade de Ciencias da Educación e do Deporte, 36310 Vigo (Spain) silviavm@uvigo.es
[4] Full professor, Universidade de Vigo, Departamento de Departamento de Didácticas Especiais, Facultade de Ciencias da Educación e do Deporte, 36310 Vigo (Spain) cayan@uvigo.es

Spanish-English translator: Collazo, Ricardo, ricardo@bonza.es

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ABSTRACT

This study aimed to determine whether primary school children can accurately monitor their heart rate (HR) through manual pulse measurement. Children aged 9 to 12 years manually assessed their HR through the carotid pulse three times in a physical education session; lying down, after submaximal effort and one minute later. Simultaneously, HR was measured by pulsometers. Of 417 children (10.58±0.93 years, 44.8% girls), 40% provided accurate values (<10% error). Concordance analysis showed wide limits of agreement (95% of measurements between 44.76% below and 78.64% above actual HR values). Sex, age and level of effort had no significant influence on the results. Primary school children are not able to accurately measure their HR through the carotid pulse.

KEY WORDS: heart rate; carotid pulse; exercise test; physical education.

RESUMEN

Este estudio tuvo como objetivo determinar si los niños de primaria pueden controlar con precisión su frecuencia cardíaca (FC) mediante la medición manual del pulso. Niños de 9 a 12 años evaluaron manualmente su FC a través del pulso carotídeo tres veces en una sesión de educación física; tumbados, tras un esfuerzo submáximo y un minuto después. Simultáneamente, se midió la FC mediante pulsómetros. De 417 niños (rango de edad 9 a 12 años, 44,8% niñas), un 40% proporcionó valores precisos (<10% de error). El análisis de concordancia mostró amplios límites de acuerdo (95% de las mediciones situadas entre un 44,76% por debajo y un 78,64% por encima de los valores reales de la FC). El sexo, la edad y el nivel de esfuerzo no tuvieron una influencia significativa en los resultados. Los niños de primaria no son capaces de medir con precisión su FC a través del pulso carotídeo.

PALABRAS CLAVE: frecuencia cardíaca; pulso carotideo; test de ejercicio; educación física.

1. INTRODUCTION

Exercise has several considerable benefits both in the physical and mental health of children. On the contrary, sedentary behaviours are negatively associated with health outcomes (Philippe Chaput & Ortega Porcel, 2020). Given the declining levels of physical activity that have been globally observed among children, governing bodies have developed guidelines providing recommendations for leading a healthier lifestyle through the promotion of its practice.

Although the optimal physical activity dose associated with improved health outcomes in children cannot be determined precisely, many of the benefits are observed with the performance of moderate-to-vigorous intensity physical activity (Landry & Driscoll, 2012). To fulfil this aim, it seems important to be able to adequately control exercise intensity, a goal that can be achieved through heart rate (HR) monitoring (Cicone, Holmes, Fedewa, MacDonald, & Esco, 2019; Yuste, García-Jiménez, & García-Pellicer, 2015).

The school is considered an ideal setting for promoting physical activity, because healthy behavior patterns are established at school-age (López, Martínez, Burruel, Ortiz, & Buñuel, 2017; Sacchetti et al., 2013). In the Spanish primary education system, physical education is one of the few subjects in the curriculum that focuses on the promotion of healthy habits. Through participation in physical education classes (PE), children in the last stage of primary education are usually introduced to the concept and utility of HR, and they are also taught how to check their pulse by means of manual palpation. However, little is known regarding to what extent children can accurately control their HR through manual pulse measurement. Studies on the validity of manual pulse rate for measuring HR have been mainly carried out with health care students or practitioners (Badra et al., 2019; Cortini, Bernucci, Moneti, Cremonini, & Rubbi, 2019; McCall, Raehl, Nelson, Haase, & Fike, 2007), although most of this research were focused on the accuracy for detecting the presence or absence or pulse.

Thus, to the very best of the authors' knowledge, no investigation on the children' skills for measuring HR through pulse check has been published so far. Under these circumstances, this study aimed to determine whether primary school children can accurately monitor their HR trough manual pulse measurement. A secondary objective was to identify if age or sex affect the accuracy of this procedure.

2. MATERIALS AND METHODS

2.1 PARTICIPANTS

The participants were 417 healthy Spanish urban children recruited from five state schools in the province of Pontevedra. Children from 6th year of primary education (between 9 and 12 years old), who did not show any medical problem that could affect the completion of the physical tests were deemed eligible for the study.

The variable sex was obtained from the registries of the school. The study conformed to the recommendations of the Declaration of Helsinki, which was reviewed and eventually approved by the ethics committee of the Faculty of Education and Sport Sciences of the University of Vigo (reference 060620).

2.2 ASSESSMENTS

2.2.1 ANTHROPOMETRY

Children's height (cm) and weight (kg) were measured with a portable stabilometer and a digital scale. Participants were requested to wear sport clothes and to take off their shoes during the measurements. BMI was calculated as weight (in kilograms) divided by the square of height (in meters).

2.2.2 HEART RATE

Heart rate was assessed three times: in a resting position with the children relaxed lying on their backs (basal HR); just after finishing a submaximal effort carried out five minutes later (the children were asked to perform either squats for 45 seconds or skipping for one minute) (Peak HR), and one minute after finishing the task (Recovery HR). Manual HR was assessed by having one child palpate the pulse from the carotids on one side of the front of the neck of a partner, just below the angle of the jaw.

The child placed their index and middle fingers over the partner's carotid artery for 15 seconds, then multiplied the result by 4 and wrote it down on a form they had been provided. In addition, HR was recorded in real time using HR monitors (Polar RS400, Kempele, Finland) connected via Bluetooth to an iPad Air 2.

2.3 PROCEDURES

The investigation was carried out during two PE lessons that took place on alternative days of the same week. During the first session, heart rate was explained to the children, and they were taught how to check the pulse by placing their fingers on their own heart, on their wrist and on their neck. Shortly after this, they were encouraged to check a partner's pulse using the same procedure.

Both anthropometric and HR measurements were performed during the second PE lesson, in the school sports facilities under the direct supervision of the PE teachers, who had been previously briefed about the study protocol. Five PE undergraduate students participated in the research explaining the basics of the tests to the children and collaborating during assessment and submaximal effort task performance.

2.4 STATISTIC ANALYSIS

Sample size was estimated to reduce the risk of type II error, both for the primary and secondary aims, using the software Power and Sample Size Calculations v 3.1.6. Chronological age was used for the statistical analyses. Data are expressed as mean ± standard deviation (SD) for quantitative variables, or as n (%) for qualitative variables. For the analysis of agreement, the calculated the difference between manual HR and monitor HR, and the limits of agreement with the Bland and Altman method (Bland & Altman, 1999).

To analyze agreement between pulse and monitor HR, we predefined acceptable limits of measurement accuracy as a percentage of the absolute difference between both methods, with three categories: <10% good, 10-20% fair and >20% poor. Previous papers about the accuracy of HR measurement devices in real life conditions followed a similar approach (Brazendale et al., 2019; Fuller et al., 2020).

Using the SPSS software, after testing the normality of the variables with the Kolmogorov-Smirnov test, we compared categorical variables with the Chi-square test, and continuous variables with Wilcoxon test, and compared the subgroups with Mann-Whitney U test or Kruskal Wallis test, as appropriate. A two-sided P value of less than 0.05 indicated statistical significance.

3. RESULT

A total of 417 children (mean age: 10.58±0.93 years; mean BMI: 19.04±3.04 kg/m2; 45% girls) volunteered for the study and completed all the assessments. Mean HR values obtained through manual assessment and HR monitor are shown in table 1. Differences in the percentages observed between both procedures ranged from 13.8% (basal HR) to 18.9% (recovery HR). Significant differences were observed between both procedures regardless of age, sex, or the phase of the submaximal test where the HR was registered. The concordance analysis showed the existence of very wide limits of agreement, indicating that 95% of the measurements taken by the children through pulse check would be between 44.76% below and 78.64% above the real HR values.

Table 1. Differences between monitor and manual heart rate assessments for the total sample and across sex, age, BMI and moment of the measurement.

	Monitor HR assessment	Manual HR assessment	Mean difference (%)	CL 95%	Between-groups differences (p-valor)
Total sample	113.43±31.44	97.96±36.1	16.94±31.48*	-44.76; 78.64	
Sex					
Female	116.03±30.78	97.25±36.20	20.18±32.88*	-44.26; 84.62	<0.001
Male	111.32±31.81	98.54±36.02	14.32±30.05*	-44.58; 73.22	
Age					
9 yo	109.87±26.09	93.30±36.20	20.33±36.65*	-51.51; 92.17	<0.001
10 yo	113.31±29.75	103.30±37.00	11.73±29.78*	-46.64; 70.09	
11 yo	113.73±32.40	98.47±36.00	16.36±31.18*	-44.75; 77.47	
12 yo	114.40±31.44	93.66±34.94	22.29±29.93*	-36.38; 80.96	
BMI					
UW and NW	111.85±31.72	96.45±36.2	17.08±31.58*	-44.82; 78.98	0.204
OW and OB	116.07±30.87	100.88±35.73	16.3±31.34*	-45.12; 77.73	
Phase					
Basal	87.18±17.64	77.02±21.29	13.86±30.72*	-46.35; 74.06	0.001
Peak	154.18±24.48	136.18±37.33	14.86±30.22*	-44.36; 74.08	
Post-effort	107.30±21.20	90.85±28.30	18.91±32.11*	-44.03; 81.85	

Values are mean ± standard deviation beats per minute unless stated otherwise. *Significant differences ($p<0.001$) comparing monitor versus manual heart rate assessments. BMI: Body Mass Index; CL: concordance limits; HR: heart rate; NW: normal weight; OB: obese; OW: overweight; SD: standard deviation; UW: underweight; YO: years old.

According to the results obtained through comparison of matched intervals (Table 2), around 40% of the children provided accurate pulse check values (<10% error). Sex, age, and the moment of the HR assessment did not have a significant influence on these results.

Table 2. Level of concordance between monitor and manual heart rate measurements in the total sample and by sex, age, BMI, and moment of measurement.

	Concordance			Betwee-groups differences (p-valor)
	Good (<10%)	**Fair (10-20%)**	**Poor (>20%)**	
Total Sample	44.24	17.95	37.81	
Sex				<0.001
Female	41	16	42	
Male	47	19	34	
Age				<0.001
9 yo	28	17	55	
10 yo	43	22	35	
11 yo	48	17	34	
12 yo	38	17	45	
BMI				0.133
UW and NW	43.42	17.80	38.78	
OW and OB	46.41	18.33	35.25	
Phase				0.061
Basal	44.75	16.98	38.27	
Peak	47.59	19.12	33.29	
Post-effort	42.74	17.85	39.41	

Values are percentages. BMI: Body Mass Index; CL: concordance limits; HR: heart rate; NW: normal weight; OB: obese; OW: overweight; SD: standard deviation; UW: underweight; YO: years old.

Bland-Altman plots (Figure 1) depicts the dispersion obtained between both procedures. A wide variety in HR values were observed, indicating mean differences above 100 beats per minute (bpm) in most cases between HR assessed manually and objectively. Bland-Altman plots stratified by age and sex can be observed in the supplementary file.

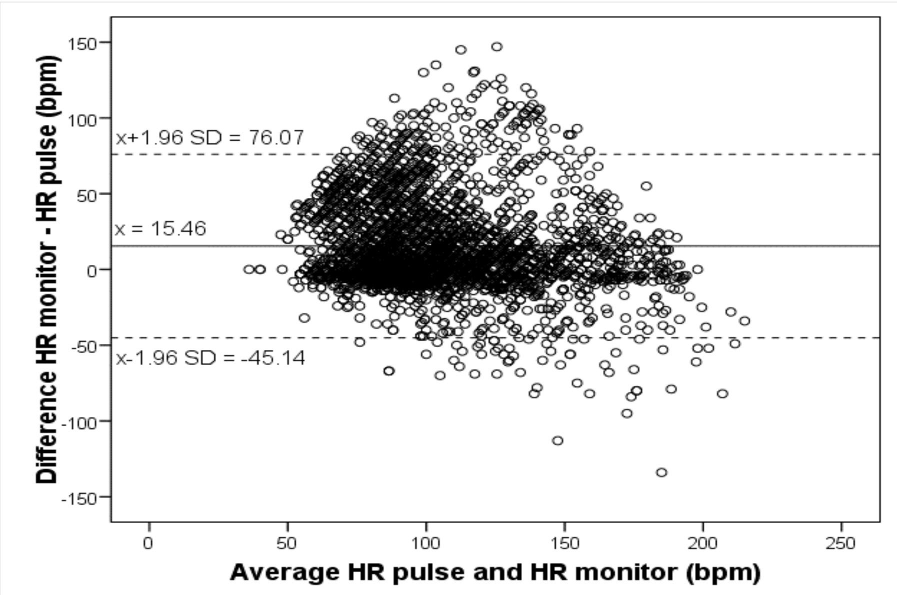

Figure 1. Bland-Altman plot of the difference between monitor HR and manual HR. Dashed lines represent limits of agreement. Continuous line represents mean difference.

Sex-stratified Bland-Altman plots are shown in Figures 2 and 3, respectively.

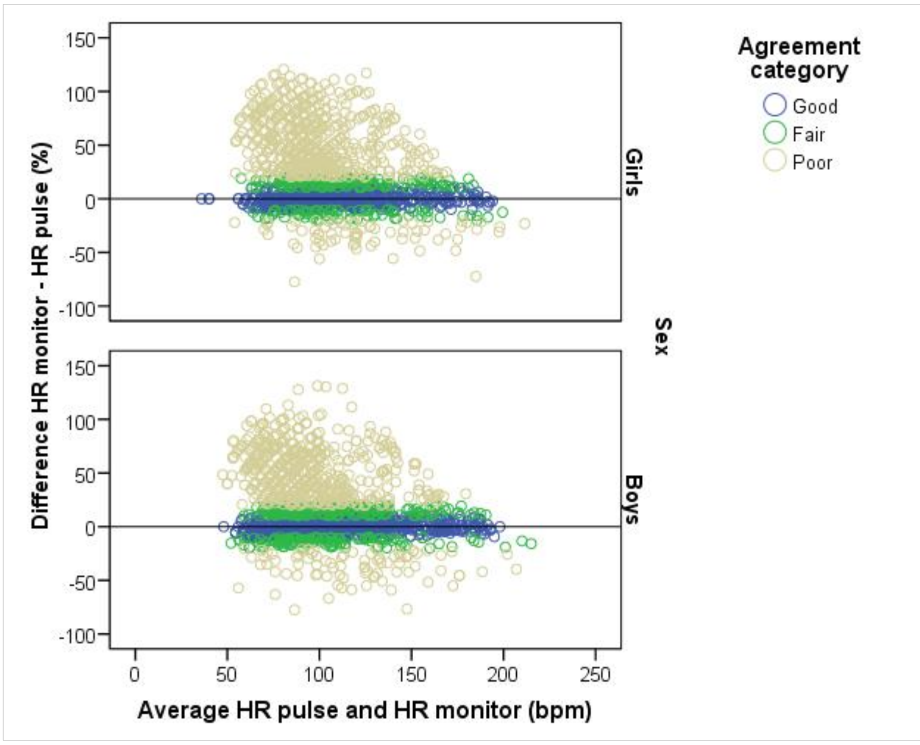

Figure 2. Bland-Altman plot of the difference between monitor HR and manual HR, stratified by sex.

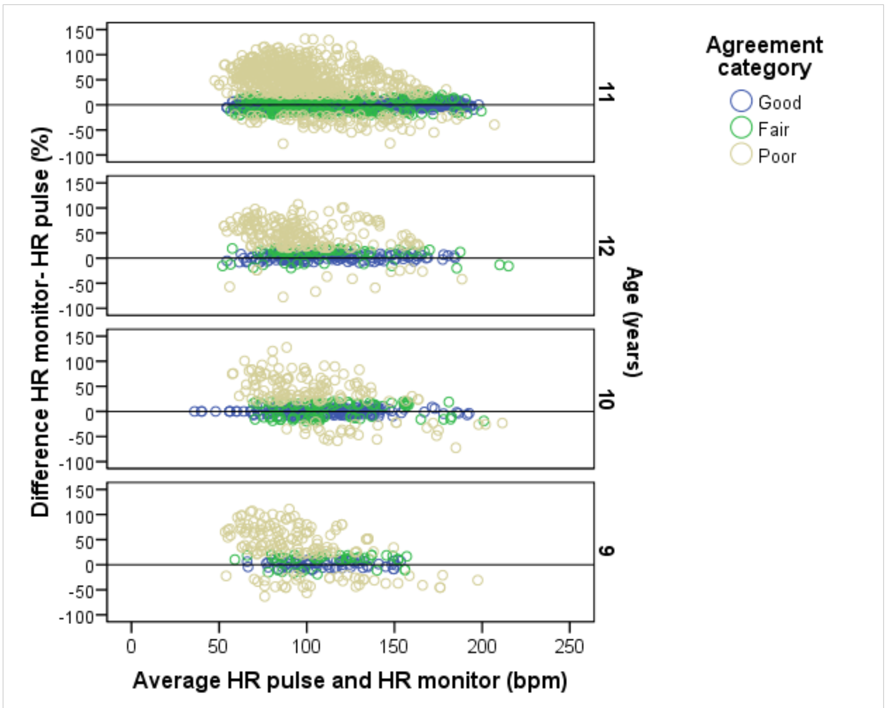

Figure 3. Bland-Altman plot of the difference between monitor HR and manual HR, stratified by age

4. DISCUSSION

This study aimed to identify where primary school children can identify HR correctly through carotid pulse check. The obtained results indicated that children have limited ability to monitor HR accurately, regardless of their age and sex. Our results are in accordance with previous findings indicating that manual measurements of HR in children, which is common practice in many settings, may provide inaccurate results (Fleming et al., 2011). This inaccuracy has also been observed among young pharmacy students, in whom it was observed a disagreement of a 5.3±4.0 bpm (range 0-18), between the results obtained when a partner' pulse was checked manually or when HR was registered through an automatic device. In this research, more than a third of the sample significantly under-estimate their partner' HR (ÇIÇEK, EAGDERI, & SUNGUR, 2019).

The identification of pulse check by palpation of the carotid artery has been con-sidered as an unreliable method for checking the presence or absence of HR, due to the amount of time needed for an accurate measurement [7]. For instance, finding the pulse in healthy volunteers took an average time of 9.46 s in individuals who have finished a first aid course (Bahr, Klingler, Panzer, Rode, & Kettler, 1997), whereas a specially trained subgroup of medical students needed 3.8 s to find the pulse in a conscious volunteer (Cw, 1994).

Our children did not assess pulse check accurately, not only while at rest, but after a submaximal effort and during a recovery period, in which the heartbeat is strong and thus, it could be more easily detected. These results are in line with previous findings suggesting that, although heartbeat perception is partially mediated by hemodynamics, there is a tendency to underestimate HR counts, regardless of the level of effort performed (Köteles et al., 2020).

Our results call into question the utility of performing HR recovery tests that require the identification of pulse check manually and which are sometimes used in the school setting for assessing fitness level (Gajewska, Kalińska, Bogdański, & Sobieska, 2015; Martínez, Álvarez, Cid, & Sanz, 2015).

First aid training should be included in primary school curriculum (Bakke, Bakke, & Schwebs, 2017).), in fact, the World Health Organization (WHO) promotes cardiopulmonary resuscitation (CPR) training for schoolchildren (Mpotos & Iserbyt, 2017). However, most of the research carried out on the ability of children to perform CPR accurately has been focused on chest compression depth, and scant information exist regarding the children ability for detecting the presence/absence of pulse.

Although checking the pulse through carotid palpation has been a cornerstone in the decision whether to perform or not CPR, recent CPR guidelines do not include pulse check in the basic life support algorithms (Olasveengen et al., 2021), and it is not one of the required resuscitation skills for laypersons, including children (Greif et al., 2021). However, teaching pulse check to children can be useful as they can improve their competence on physical examination and understand the basics of the physiology of circulation. When adapted to the age of the students, this could help to improve their ability to perform the skills and understand the underpinning theory of CPR (Emad, 2018).

On a positive note, we found that around 40% of the children showed a 10% error rate, when comparing manual to HR monitor measurements. This could indicate that, with a proper training period, primary children might improve their ability to check the pulse rate accurately. For instance, on sample of pharmacy students it was observed that after performing a patient assessment laboratory course, the proportion of participants who were able to provide an accuracy HR manual measurement within an acceptable margin of error, improved from 52% to 79%. Correlation values between HR assessed manually and through an automatic monitor also improved (from 0.672 to 0.907).

In the light of all this, for an accurate control of exercise intensity, it seems advisable to teach children to differentiate between light, moderate and vigorous effort, based on breathing patterns, rather to rely on their pulse check skills. However, there are several limitations in this research that should be considered for a proper interpretation of this conclusion. First, children did not assess their own pulse. Secondly, 15 seconds might not be enough for an accurate pulse check, since the shorter the time, the longer the error (Almeida, Bottino, Ramos, & Araujo, 2019). Finally, we measured HR at rest under real life conditions, rather than following medical procedure (i.e., check pulse after 20 minutes of rest on a controlled environment and repeat twice) (Ulrich Vogel, Wolpert, & Wehling, 2004).

5. CONCLUSIONS

Primary school children are not able to measure accurately their HR through carotid pulse. Further studies should seek whether their skills for checking the pulse manually could be improved after a brief training course.

REFERENCES

Almeida, M., Bottino, A., Ramos, P., & Araujo, C. G. (2019). Measuring heart rate during exercise: from artery palpation to monitors and apps. *International Journal of Cardiovascular Sciences, 32*, 396-407.

Badra, K., Coutin, A., Simard, R., Pinto, R., Lee, J. S., & Chenkin, J. (2019). The POCUS pulse check: A randomized controlled crossover study comparing pulse detection by palpation versus by point-of-care ultrasound. *Resuscitation, 139*, 17-23.

Bahr, J., Klingler, H., Panzer, W., Rode, H., & Kettler, D. (1997). Skills of lay people in checking the carotid pulse. *Resuscitation, 35*(1), 23-26.

Bakke, H. K., Bakke, H. K., & Schwebs, R. (2017). First-aid training in school: amount, content and hindrances. *Acta Anaesthesiologica Scandinavica, 61*(10), 1361-1370.

Bland, J. M., & Altman, D. G. (1999). Measuring agreement in method comparison studies. *Statistical methods in medical research, 8*(2), 135-160.

Brazendale, K., Decker, L., Hunt, E. T., Perry, M. W., Brazendale, A. B., Weaver, R. G., & Beets, M. W. (2019). Validity and wearability of consumer-based fitness trackers in free-living children. *International journal of exercise science, 12*(5), 471.

ÇIÇEK, E., EAGDERI, S., & SUNGUR, S. (2019). Oxynoemacheilus phoxinoides (Erk'akan, Nalbant & Özeren, 2007): a junior synonym of Oxynoemacheilus angorae (Steindachner, 1897). *FishTaxa, 4*(1), 13-17.

Cicone, Z. S., Holmes, C. J., Fedewa, M. V., MacDonald, H. V., & Esco, M. R. (2019). Age-based prediction of maximal heart rate in children and adolescents: A systematic review and meta-analysis. *Research quarterly for exercise and sport, 90*(3), 417-428.

Cortini, C., Bernucci, L., Moneti, L., Cremonini, B. V., & Rubbi, I. (2019). Reliability of pulsioxymetry in the assessment of heart rate compared to other non invasive methods. *Assistenza Infermieristica e Ricerca: AIR, 38*(1), 23-29.

Cw, F. (1994). The ability of health professionals to check the carotid pulse. *Circulation, 90*(1), 288.

Emad, H. (2018). Stem Cell Therapy for Vascular Disorders. *Vascular & Endovascular Review, 1*.

Fleming, S., Thompson, M., Stevens, R., Heneghan, C., Plüddemann, A., Maconochie, I., . . . Mant, D. (2011). Normal ranges of heart rate and respiratory rate in children from birth to 18 years of age: a systematic review of observational studies. *The lancet, 377*(9770), 1011-1018.

Fuller, D., Colwell, E., Low, J., Orychock, K., Tobin, M. A., Simango, B., . . . Cullen, K. (2020). Reliability and validity of commercially available wearable devices for measuring steps, energy expenditure, and heart rate: systematic review. *JMIR mHealth and uHealth, 8*(9), e18694.

Gajewska, E., Kalińska, K., Bogdański, P., & Sobieska, M. (2015). Cardiorespiratory endurance in relation to body mass in Polish rural children: Preliminary report. *Homo, 66*(3), 278-285.

Greif, R., Lockey, A., Breckwoldt, J., Carmona, F., Conaghan, P., Kuzovlev, A., . . . Scapigliati, A. (2021). European resuscitation council guidelines 2021: education for resuscitation. *Resuscitation, 161*, 388-407.

Köteles, F., Éliás, I., Szabolcs, Z., Körmendi, J., Ferentzi, E., & Szemerszky, R. (2020). Accuracy of reproduction of physical training load is not associated with resting heartbeat perception in healthy individuals. *Biological Psychology, 150*, 107831.

Landry, B. W., & Driscoll, S. W. (2012). Physical activity in children and adolescents. *PM&R, 4*(11), 826-832.

López, J. A. H., Martínez, P. Y. O., Burruel, R. Z., Ortiz, L. R. M., & Buñuel, P. S.-L. (2017). Moderate-to-vigorous physical activity during recess and physical education among mexican elementary school students. *Retos: nuevas tendencias en educación física, deporte y recreación*(31), 137-139.

Martínez, d. H. V., Álvarez, B. M., Cid, Y. L., & Sanz, A. I. (2015). Health aspects of physical education in the community of Madrid (Spain). *Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte, 15*(57), 10-12.

McCall, K. L., Raehl, C., Nelson, S., Haase, K., & Fike, D. S. (2007). Evaluation of pharmacy students' blood pressure and heart rate measurement skills after completion of a patient assessment course. *American Journal of Pharmaceutical Education, 71*(1).

Mpotos, N., & Iserbyt, P. (2017). Children saving lives: Training towards CPR excellence levels in chest compression based on age and physical characteristics. *Resuscitation, 121*, 135-140.

Olasveengen, T. M., Semeraro, F., Ristagno, G., Castren, M., Handley, A., Kuzovlev, A., . . . Soar, J. (2021). European resuscitation council guidelines 2021: basic life support. *Resuscitation, 161*, 98-114.

Philippe Chaput, J., & Ortega Porcel, F. B. (2020). *2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5–17 years: summary of the evidence*.

Sacchetti, R., Ceciliani, A., Garulli, A., Dallolio, L., Beltrami, P., & Leoni, E. (2013). Effects of a 2-year school-based intervention of enhanced physical education in the primary school. *Journal of School Health, 83*(9), 639-646.

Ulrich Vogel, C., Wolpert, C., & Wehling, M. (2004). How to measure heart rate? *European Journal of Clinical Pharmacology, 60*(7).

Yuste, J., García-Jiménez, J., & García-Pellicer, J. (2015). Intensidad de las clases de educación física en adolescentes/Intensity of Physical Education Classes in Adolescents. *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, 15*(58), 309-323.