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Exercise Intensity and Lactate Kinetics in Children Aged 8–12 Years

Intensidad del ejercicio y cinética del lactato en infantes de 8 a 12 años

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Abstract

Background. The assessment of exercise intensity in pediatric populations is limited by developmental differences in the metabolic, cardiovascular, and endocrine systems, which challenge adult-derived models for interpreting lactate. Objective. To evaluate lactate kinetics, $\dot{V}O_2max$, and cardiovascular responses in school-aged children aged 8 to 12 years (n=24), considering sex and biological maturation, and to determine the optimal time for lactate measurement. Methods. A prospective, interventional, pre- and post-test study was conducted to determine lactate dynamics at rest and immediately after exercise, between 5 and 7 minutes and after 10 minutes. Participants from central Mexico were stratified by age (8-10 vs. 10-12 years) and sex (female and male) (n=24), and were selected from the city. Anthropometric, cardiovascular, and metabolic variables were analyzed. Statistical analysis included one-way ANOVA, post hoc comparisons, and Pearson correlation. Results: Significant differences were observed between age groups for $\dot{V}O_2max$ ($F=6.12$; $p<0.01$) and lactate ($F=7.45$; $p=0.008$). Male infants showed a higher $\dot{V}O_2max$ than female infants ($p<0.05$). The lactate peak occurred between 3 and 5 minutes after exercise. A significant correlation was observed between lactate and heart rate ($r=0.52$; $p<0.01$). Discussion: These findings confirm a growth-stage-dependent metabolic response and support the use of standardized protocols for lactate measurement. Ethical considerations should guide invasive testing in pediatric populations, favoring the use of non-invasive methods such as heart rate monitoring.

Keywords: Exercise intensity in puberty, lactate kinetics, VO_2max, cardiovascular correlation.

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Resumen

Antecedentes. La evaluación de la intensidad del ejercicio en poblaciones pediátricas, está limitada por diferencias de desarrollo en los sistemas metabólico, cardiovascular y endocrino, que son diferentes a la de lactato de adultos. Objetivo. Evaluar la cinética del lactato, $\dot{V}O_2max$ y las respuestas cardiovasculares en niños y niñas de 8 a 12 años, (n=24) considerando el sexo, y maduración biológica, en el post ejercicio y determinar el momento óptimo en su medición. Métodos. Se realizó un estudio de tipo intervencional, prospectivo, pre y post prueba para determinar la dinámica de lactato en reposo y en el post ejercicio inmediato, entre 5 y 7 minutos y después de 10 minutos. Los participantes del centro de México fueron estratificados por edad (8-10 vs 10-12 años) y sexo (femeninos y masculinos) (n=24), pertenecientes a los seleccionados de la ciudad. Se analizaron variables antropométricas, cardiovasculares y metabólicas. El análisis estadístico incluyó ANOVA unidireccional, comparaciones post hoc y correlación de Pearson. Resultados. Se observaron diferencias significativas entre los grupos de edad para el $\dot{V}O_2max$ ($F=6.12$; $p<0.01$) y el lactato ($F=7.45$; $p=0,008$). Los infantes masculinos mostraron un $\dot{V}O_2max$ mayor que el sexo femenino($p<0.05$). El pico de lactato se produjo entre los 3 y 5 minutos posteriores al ejercicio. Se observó una correlación significativa entre el lactato y la frecuencia cardíaca ($r=0.52$; $p<0.01$). Discusión. Los hallazgos confirman una respuesta metabólica dependiente de la etapa de crecimiento y respaldan el uso de protocolos estandarizados para la medición del lactato. Las consideraciones éticas deben guiar las pruebas invasivas en poblaciones pediátricas, mediante la utilización de mecanismos no invasivos, como la frecuencia cardiaca. Conclusión. El nivel de lactato alcanza sus niveles a los 5 minutos, por lo que es el tiempo más adecuado para su medición y se correlaciona con variables cardiovariables confiablemente como la frecuencia cardiaca.

Palabras clave: Intensidad ejercicio puberal, cinética lactato, $\dot{V}O_2max$, correlación cardiovascular.

Introduction

Exercise physiology in children differs substantially from adulthood due to developmental changes in cardiovascular regulation, glycolytic capacity, and endocrine maturation (Rowland, 2005; Armstrong y Welsman, 2001). Children generally demonstrate lower glycolytic activity, reduced phosphofructokinase activity, and faster lactate clearance than older (Falk y Dotan, 2006; Brooks, 2020). Consequently, blood lactate responses during exercise are influenced by age, sex, pubertal development, and aerobic fitness (Beneke et al., 2011). Blood lactate measurement has been widely used to estimate exercise intensity during pediatric exercise testing (Hebestreit et al., 1993). However, controversy remains regarding the optimal timing for lactate assessment after exercise. Some investigations recommend immediate post-exercise sampling, whereas others indicate that peak lactate concentrations in children occur between 3 and 5 min after exercise cessation (Dotan et al., 2000; Ratel, 2002).

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Additional studies suggest that delayed peaks between 7 and 10 min may occur following supramaximal exercise [9]. These differences may be explained by muscle fiber recruitment, exercise modality, maturation status, and lactate transport kinetics (Gladden, 2004).

Blood lactate has historically been interpreted as a proxy for anaerobic metabolism and exercise intensity. Nonetheless, contemporary perspectives have redefined lactate as a central metabolic intermediate involved in energy shuttling, redox balance, and cellular signaling (Brooks, 2020). This paradigm shift is particularly relevant in pediatric populations, where lactate accumulation is not solely dependent on exercise intensity but is modulated by enzymatic madurity, substrate utilization, and hormonal influences.

Exercise intensity evaluation in children requires a paradigm distinct from adult physiology due to developmental differences in metabolic pathways and cardiovascular regulation. The importance of this study lies in the need to intervene in physical activity programs, through the validation of some physiological variables, such as heart rate, to identify the intensity of exercise. By metabolically validating this variable through lactate measurement, the need to measure this variable in children under 12 years of age is avoided. Additionally, it allows understanding the interrelation of cardiovascular and metabolic variables to properly adjust the training methodology for infants.

Despite advances in pediatric exercise science, methodological inconsistencies persist, particularly regarding the optimal timing of lactate measurement following exercise. Furthermore, limited normative data exist for integrated physiological profiling in children, especially within specific populations. The importance of understanding lactate dynamics in infants lies in relating it to other cardiovascular variables, such as heart rate and $\dot{V}O2$ max, to avoid being intrusive with infants as much as possible. Therefore, the present study aims to provide a comprehensive, integrative analysis of exercise intensity markers, including lactate kinetics, $\dot{V}O_2max$, cardiovascular responses, and anthropometric characteristics, while also addressing ethical considerations associated with invasive measurements in minors.

Methods

Participants belonged to basic teams from municipalities from León and Pachuca, México, profesional soccer team, in good clinical health following a medical evaluation—an essential requirement for participating in this elite group. They had at least one year of prior sports experience. Informed consent was obtained from the parents, who were informed of the research procedures, risks, and benefits in accordance with the Declaration of Helsinki and Mexican regulations regarding human research. Approval was obtained from the Bioethics Committee of the León Municipal Sports Commission. They were invited through their parents, considering ethical and regulatory international guidelines, and their informed consent was obtained, explaining the benefits, risks, and procedures to be carried out. The sample were obtained from an universe of 88 members. The Bioethics Committee of the sports authorities gave its approval, stipulating monitoring by trained physicians and requesting a weekly report of the results, finally a repeat of the study to ensure its effectiveness and future interventions in the athletes selected from their physical education classes. Individuals presenting with an intercurrent illness or a desire not to continue in the study were excluded.

They were divided into four groups (n=24): boys aged 8–10 years-old, girls aged 8–10 years old, boys aged 10–12 years, and girls aged 10–12 years, (n=6 participants in each group). The sample size (n) is determined by the formula $n = z^2s^2/d^2$, where z^2 represents the confidence level at an alpha of 95%, s^2 is the post-exercise lactate variance, and d^2 is the error margin encompassing pre-analytical, analytical, and total analytical variations. The sample was obtained based on the population variance in the main variable of the study (serum lactate at maximum effort) according to previous studies, in rest, at 3-5, 10 minutes and 20 minutes, after exercise. A puncture was performed on the pad of the right middle finger—following aseptic preparation of the area by washing with soap and water and alcohol—using a capillary blood testing device (Accutrend lactate meter) at the specified intervals.

Anthropometric variables included body weight, height, body mass index (BMI), body fat percentage estimated through validated skinfold equations, and lean body mass calculated accordingly (Slaughter et al., 1988; Flynn et al., 2017; Malina et al., 2004; Bar-Or, 1996; Wilmore, 2020; Rivera-Brown y Frontera, 2012; Bailey et al., 1995). All the participants, participated in a Bruce protocol according with their age. Cardiovascular variables included resting heart rate, systolic and diastolic blood pressure measured using standardized oscillometric techniques, mean arterial pressure calculated by conventional formulas, pulse wave velocity as an index of arterial stiffness and maximal heart rate (Flynn, 2017). Additionally, muscle stiffness was considered as a proxy of neuromuscular mechanical properties and measure with hand wearable portable instrument (Samsung GT-2). $\dot{V}O_2max$ was estimated using the multistage shuttle-run test validated in children (Léger, 1988). Blood lactate was obtained using capillary sampling and portable enzymatic analyzers (Tanner, 2010).

Statistical analysis included one way ANOVA and Tukey post hoc analysis, Pearson correlation analysis, and multiple linear regression modeling. Pre-analytical variables included hydration status, environmental temperature, fasting duration, emotional stress, and pubertal status (ACSM, 2021). Confidence level was fixed at alpha of 95%.

Results

The table 1 describe the anthropometric characteristics of participants. This table shows that there were no differences in age or body mass index, which is related to the characteristics of the participants. It is also noteworthy that there was a statistically significant difference between men and women, with higher values found in older participants.

Table 1.
Age and anthropometric characteristics of the participants.

Variable	Boys 8-10 y	Girls 8-10 y	Boys 11-12 y	Girls 11-12 y	95%CI	p-value
Age (years)	9.1±0.6	9.0±0.5	11.4±0.5	11.3±0.4	8.9±11.5	0.41
Body Mass (Kg)	31.8±4.2	30.5±3.9	41.2±5.1	39.8±4.8	30.7±42.7	0.03
Height (cm)	134.6±5.8	133.2±5.3	148.9±6.2	147.1±5.9	132.4±150.2	0.04
BMI (Kg*m2)	17.5±1.8	17.2±1.6	18.6±1.9	18.3±1.7	16.9±18.9	0.267

Source: Compiled by the author.

The table 2 and figure 1, shows the variables measured simultaneously in the data collection of the study. All physiological variables were significantly ($p<0.05$) higher in the male groups than in the female groups, and the highest values were found in the larger men.

Table 2.
Pre and Post-exercise cardio physiologic variables and dynamics lactacte. (mean+SD).

Variable	Boys 8-10 y	Girls 8-10 y	Boys 11-12 y	Girls 11-12 y	p-value
Resting HR (bpm)	86.0±8.0	90.0±9.0	80.07±7.0	84.0+8.0	0.03
Mean Arterial Pressure(mm/Hg)	76.0+7.0	77.0+7.0	82.0+8.0	81.0+8.0	0.04
Pulse Wave Velocity (m/s)	4.1+0.5	4.2+0.5	4.5+0.5	4.7+0.5	0.04
$\dot{V}O_2max$ max (ml/Kg/min)	49.5+5.5	46.3+0.5	52.08+6.0	48.0+7.0	0.01
Lactate serial (mMol/L	5.4+1.0	5.0+0.9	7.1+1.2	6.5+1.1	0.01

Source: Compiled by the author.

Male aged 10–12 years demonstrated higher $\dot{V}O_2max$ compared to younger children (mean difference ≈ 4.5 ml/kg/min, $p=0.01$). Lactate concentrations were also higher in older children ($p=0.008$), indicating increased glycolytic activity whereas girls presented higher body fat percentages. Peak lactate values were consistently observed at 3–5 minutes post-exercise. Sex differences were evident, with boys showing higher $\dot{V}O_2max$ ($p<0.05$) and lower body fat percentage, while girls exhibited higher adiposity and slightly lower aerobic capacity.

Figure 1 combined values of four gruoups for lactate kinetics analysis revealed that peak lactate occurred consistently at 3–5 minutes post-exercise, confirming that immediate measurements underestimate peak values, while later measurements reflect clearance dynamics. After 10 and 20 minutes, the values were returned to lactate pre-exercise.

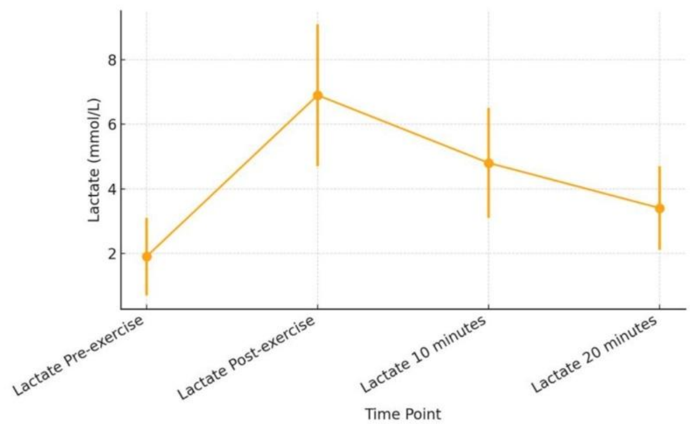

Figure 1. Dynamic of capillar lactate of all the participants (mean + SD).

Source: Compiled by the author.

Table 3 indicate the values of matrix correlation between the lactate and cardiovascular values. Peak lactate values were consistently observed at 3–5 minutes post-exercise. A significant positive correlation between lactate and heart rate was identified ($r \approx 0.45–0.60$, $p < 0.05$). Sex differences were evident, with boys showing higher $\dot{V}O_2max$ ($p<0.05$) (Table 3).

Table 3.
Correlation matrix between lactate and cardiovascular values during study.

Variable	Lactate	$\dot{V}O_2max$	HR	MAP	PWV
Lactate	1.00	-0.72	0.68	0.41	0.36
$\dot{V}O_2max$	-0.72	1.00	-0.81	-0.44	-0.38
HR	0.68	-0.81	1.00	0.52	0.46
MAP	0.41	-0.44	0.52	1.00	0.49
PWV	0.36	-0.38	0.46	0.49	1.00

Source: Compiled by the author.

$\dot{V}O_2max$ was associated with blood lactate in boys and girls. Boys showed a stronger correlation compared with girls ($p<0.05$).

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Lactate was correlate with V̇O2max, Heart Rate (HR), Mean Arterial Pressure (MAP) and Pulse Wave Velocity (PWV) The determinant coefficient was R2= 52; p<0.05. Boys showed a global significant association between $\dot{V}O_2max$ and blood lactate ($r \approx 0.55$, $p < 0.01$), whereas girls demonstrated a moderate relationship ($r \approx 0.48$, $p < 0.05$).

Discussion

The present analysis supports previous evidence indicating that pediatric exercise responses differ from adult physiology because of maturational differences in metabolic and cardiovascular regulation (Rowland, 2005; Beneke, et al., 2011). Lower glycolytic enzyme activity and more rapid lactate clearance may partially explain the lower lactate concentrations typically observed in children (Brooks, 2020; Beneke, 2011). The controversy regarding lactate timing after exercise remains unresolved. Immediate post-exercise measurements may underestimate peak lactate because lactate efflux from active muscle continues during early recovery (Dotan, et al., 2000). Several investigations support sampling between 3 and 5 min after exercise to identify peak lactate responses more accurately (Ratel et al., 2002; Armstrong y Barker, 2011). Pubertal hormonal activation modifies muscle mass, glycolytic activity, and aerobic performance, particularly in boys (Malina et al., 2004). Pulse wave velocity increased modestly with age, suggesting early vascular adaptation during maturation (Reusz, 2010). Ethical concerns associated with repeated blood sampling in children younger than 12 years must also be considered (World Medical Association, 2013). Future pediatric exercise physiology studies should integrate metabolic, cardiovascular, and maturational variables using longitudinal designs.

The present study also provides a comprehensive integrative perspective on exercise intensity assessment in children, highlighting the importance of developmental physiology in interpreting metabolic and cardiovascular responses. The findings reinforce the concept that pediatric populations cannot be evaluated using adult-derived models, as their physiological responses are fundamentally shaped by maturation processes .

The integrative analysis revealed clear developmental and sex-specific differences across anthropometric, cardiovascular, and metabolic domains. Children aged 10–12 years exhibited higher body mass, greater height, and increased BMI compared to younger children, reflecting normal growth patterns. Body fat percentage was consistently higher in girls than in boys across both age groups, while lean body mass was greater in boys, particularly in the older group, consistent with emerging hormonal influences (Rowland, 2005; Armstrong y Welsman, 2001; Falk y Dotan, 2006; Hebestreit, 1993).

Cardiovascular variables demonstrated maturation-related adaptations. Resting heart rate tended to decrease with age, indicating improved cardiac efficiency, while systolic blood pressure showed a modest increase consistent with growth-related hemodynamic changes. Pulse wave velocity exhibited a slight increase with age, suggesting progressive vascular adaptation, although values remained within normal pediatric ranges (Hebestreit, 1993, Ratel, et al., 2002; Armstrong y Barker, 2011; Flynn, 2017).

Metabolically, lactate concentrations were lower in younger children and increased in the 10–12-year group, supporting the notion of enhanced glycolytic capacity with maturation. Peak lactate values were most accurately captured at 3–5 minutes post-exercise, whereas immediate measurements underestimated peak levels and later measurements reflected clearance dynamics. VO_2max values were higher in boys compared to girls and increased with age, reflecting both physiological maturation and differences in body composition (Brooks, 2020; Hebestreit et al., 1993; Dotan, 2000; Armstrong y Barker, 2011; Gladden, 2004).

A positive correlation between lactate and heart rate was observed, indicating a coupling between metabolic and cardiovascular responses during exercise. This relationship supports the integrative nature of exercise intensity regulation in pediatric and Young populations (Ratel, 2002; Armstrong y Barker, 2011; Gladden, 2004; ACSM, 2021; Malina et al., 2004, Reusz et al., 2010).

One of the key findings is the lower lactate levels observed in younger children, which can be attributed to reduced glycolytic enzyme activity, particularly phosphofructokinase, and a greater reliance on oxidative metabolism (Reusz et al., 2010). This metabolic profile results in a diminished capacity for anaerobic energy production and a faster clearance of lactate, which has important implications for exercise testing and training prescription.

The transition to early puberty is associated with increased lactate production, reflecting enhanced glycolytic capacity driven by hormonal changes, including increased testosterone and growth hormone levels. These changes also contribute to improvements in VO_2max and overall exercise performance. The observed sex differences, with boys demonstrating higher VO_2max and lower body fat, are consistent with known physiological differences emerging during this developmental period (Hebestreit, 1993; Ratel, 2002; Bar-Or, 1996; Riddell, 2008).

A central methodological contribution of this study is the clarification of the optimal timing for lactate measurement. The identification of the 3–5 minute window as the most accurate representation of peak lactate aligns with physiological principles of lactate diffusion and systemic distribution, as well as previous empirical findings (Riddell, 2008.

This finding helps resolve longstanding inconsistencies in the literature and provides a standardized approach for future studies.

Morin's complexity model (figure 2) indicates the interaction of different factors that must be considered in this type of study. It demonstrates that exercise intensity, control systems, and metabolic processes decisively influence the expected response in post-exercise lactate measurements in maximal exercise. The final effect of lactate kinetics is related to metabolism and neuroendocrine regulation, particularly during the recovery phase.

This is linked to a key indicator: heart rate, used to assess exercise intensity. The hemodynamic response of the cardiovascular system is associated with pulse wave velocity, an indicator of the adaptability of peripheral blood vessels.

This adaptability is also regulated by the autonomic regulation of the cardiocirculatory system during acute exercise, which is linked to the metabolic

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clearance of lactate oxidation and its reuse by the muscle, heart, and liver through the Cori cycle. This process, taken together, is a significant determinant for detecting lactate levels in athletes and thus establishing the intensity of physical exertion.

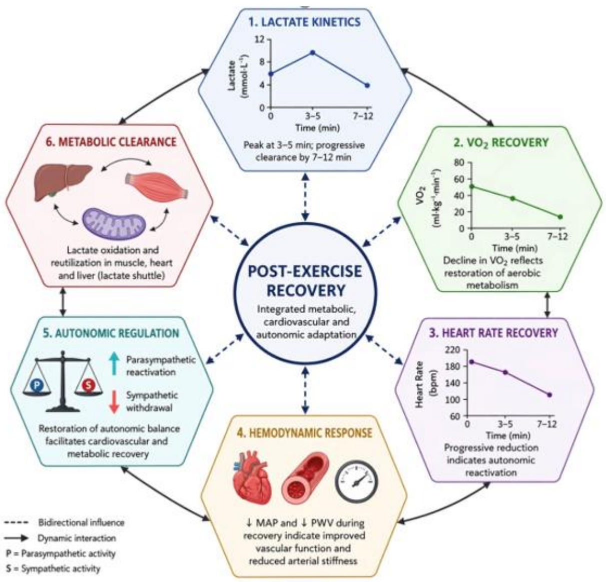

Figure 2. Hypothetic Morin's scheme demonstrating the interaction of factors in post-exercise lactate expression in youth athletes subjected to maximum intensity exercise.

To understand lactate dynamics, one must consider the factors and conditions outlined in the Morin diagram—specifically peak oxygen consumption, heart rate recovery, hemodynamic response, autonomic regulation, hepatic function, and the regulation of lactate metabolism—which collectively determine the final capillary lactate value observed in this study.

Importantly, this study also raises critical ethical considerations regarding the measurement of blood lactate in children. The collection of capillary blood samples, although minimally invasive, involves discomfort and potential anxiety, particularly in younger children. Ethical guidelines for pediatric research emphasize the need to minimize harm, ensure informed consent and assent, and justify the necessity of invasive procedures (World Medical Association. Declaration of Helsinki, 2013). The use of lactate measurement in children must therefore be carefully considered, balancing scientific value against participant burden (Riddell 2008). Alternative non-invasive markers, such as heart rate monitoring and perceived exertion scales, may be preferable in certain contexts. Moreover, when lactate measurement is deemed necessary, protocols should be optimized to reduce the number of samples and ensure appropriate support for participants.

The results confirm that pediatric metabolic responses are developmentally regulated. Lower lactate levels in younger children reflect reduced glycolytic enzyme activity, consistent with previous findings ((Riddell 2008). The increase in lactate during early puberty is attributable to hormonal changes that enhance glycolytic capacity and muscle mass.

The identification of the 3–5 minute window as optimal for lactate measurement resolves longstanding methodological inconsistencies and aligns with physiological principles of lactate diffusion and systemic circulation

Conclusions

Blood lactate assessment remains a useful physiological marker for exercise intensity determination in children. Peak lactate concentrations appear most consistently between 3 and 5 min after exercise.

Maturation, sex, body composition, and aerobic fitness significantly influence pediatric lactate kinetics. Integrated cardiovascular and metabolic assessment may improve pediatric exercise prescription and performance monitoring.

However, exercise intensity assessment in children requires a developmentally informed approach that integrates metabolic, cardiovascular, and maturational variables. Blood lactate remains a valuable marker when interpreted within this context, particularly when measured at 3–5 minutes post-exercise. Its use must be carefully justified in pediatric populations due to ethical considerations. The integration of VO_2max, lactate, and cardiovascular parameters provides a comprehensive framework for understanding exercise responses in children and supports the development of age-appropriate assessment models.

Thus, lactate is a valid marker of exercise intensity in children when interpreted within a developmental framework. The optimal timing of measurement is 3–5 minutes post-exercise.

References

American College of Sports Medicine. (2021). *ACSM's guidelines for exercise testing and prescription* (11th ed.). Wolters Kluwer.

Armstrong, N., & Barker, A. R. (2011). Endurance training and elite young athletes. In N. Armstrong & A. M. McManus (Eds.), *The elite young athlete* (Medicine and Sport Science, Vol. 56, pp. 59–83). Karger. https://doi.org/10.1159/000320633

Armstrong, N., & Welsman, J. R. (2001). Peak oxygen uptake in relation to growth and maturation in 11- to 17-year-old humans. *European Journal of Applied Physiology, 85*(6), 546–551. https://doi.org/10.1007/s004210100485

Bailey, R. C., Olson, J., Pepper, S. L., Porszasz, J., Barstow, T. J., & Cooper, D. M. (1995). The level and tempo of children's physical activities: An observational study. *Medicine & Science in Sports & Exercise, 27*(7), 1033–1041. https://doi.org/10.1249/00005768-199507000-00012

Bar-Or, O. (Ed.). (1996). *The child and adolescent athlete*. Blackwell Science.

Beneke, R., Leithäuser, R. M., & Ochentel, O. (2011). Blood lactate diagnostics in exercise testing and training. *International Journal of Sports Physiology and Performance, 6*(1), 8–24. https://doi.org/10.1123/ijspp.6.1.8

Brooks, G. A. (2020). Lactate as a fulcrum of metabolism. *Redox Biology, 35*, Article 101454. https://doi.org/10.1016/j.redox.2020.101454

Dotan, R., & Falk, B. (2000). Blood lactate accumulation in children and adolescents. *Pediatric Exercise Science, 12*, 94–105.

Falk, B., & Dotan, R. (2006). Child–adult differences in the recovery from high-intensity exercise. *Exercise and Sport Sciences Reviews, 34*(3), 107–112. https://doi.org/10.1249/00003677-200607000-00004

Flynn, J. T., Kaelber, D. C., Baker-Smith, C. M., Blowey, D., Carroll, A. E., Daniels, S. R., de Ferranti, S. D., Dionne, J. M., Falkner, B., Flinn, S. K., Gidding, S. S., Goodwin, C., Leu, M. G., Powers, M. E., Rea, C., Samuels, J., Simasek, M., Thaker, V. V., Urbina, E. M., & Subcommittee on Screening and Management of High Blood Pressure in Children. (2017). Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics, 140*(3), Article e20171904. https://doi.org/10.1542/peds.2017-1904

Gladden, L. B. (2004). Lactate metabolism: A new paradigm for the third millennium. *The Journal of Physiology, 558*(1), 5–30. https://doi.org/10.1113/jphysiol.2003.058701

Hebestreit, H., Mimura, K., & Bar-Or, O. (1993). Recovery of muscle power after high-intensity short-term exercise: Comparing boys and men. *Journal of Applied Physiology, 74*(6), 2875–2880. https://doi.org/10.1152/jappl.1993.74.6.2875

Kenney, W. L., Wilmore, J. H., & Costill, D. L. (2020). *Physiology of sport and exercise* (7th ed.). Human Kinetics.

Léger, L. A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Sciences, 6*(2), 93–101. https://doi.org/10.1080/02640418808729800

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity* (2nd ed.). Human Kinetics.

McArdle, W. D., Katch, F. I., & Katch, V. L. (2022). *Exercise physiology: Nutrition, energy, and human performance* (9th ed.). Wolters Kluwer.

Poole, D. C., Rossiter, H. B., Brooks, G. A., & Gladden, L. B. (2021). The anaerobic threshold: 50+ years of controversy. *The Journal of Physiology, 599*(3), 737–767. https://doi.org/10.1113/JP279963

Ratel, S., Bedu, M., Hennegrave, A., Doré, E., & Duché, P. (2002). Effects of age and recovery duration on peak power output during repeated cycling sprints. *International Journal of Sports Medicine, 23*(6), 397–402. https://doi.org/10.1055/s-2002-33737

Reusz, G. S., Cseprekal, O., Temmar, M., Kis, E., Cherif, A. B., Thaleb, A., Fekete, A., Szabó, A. J., Benetos, A., & Salvi, P. (2010). Reference values of pulse wave velocity in healthy children and teenagers. *Hypertension, 56*(2), 217–224. https://doi.org/10.1161/HYPERTENSIONAHA.110.152686

Riddell, M. C. (2008). The endocrine response and substrate utilization during exercise in children and adolescents. *Journal of Applied Physiology, 105*(2), 725–733. https://doi.org/10.1152/japplphysiol.00031.2008

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Rivera-Brown, A. M., & Frontera, W. R. (2012). Principles of exercise physiology: Responses to acute exercise and long-term adaptations to training. *PM&R, 4*(11), 797–804. https://doi.org/10.1016/j.pmrj.2012.10.007

Rowland, T. W. (2005). *Children's exercise physiology* (2nd ed.). Human Kinetics.

Slaughter, M. H., Lohman, T. G., Boileau, R. A., Horswill, C. A., Stillman, R. J., Van Loan, M. D., & Bemben, D. A. (1988). Skinfold equations for estimation of body fatness in children and youth. *Human Biology, 60*(5), 709–723.

Tanner, R. K., Fuller, K. L., & Ross, M. L. R. (2010). Evaluation of three portable blood lactate analysers: Lactate Pro, Lactate Scout and Lactate Plus. *European Journal of Applied Physiology, 109*(3), 551–559. https://doi.org/10.1007/s00421-010-1379-9

World Medical Association. (2013). World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA, 310*(20), 2191–2194. https://doi.org/10.1001/jama.2013.281053