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Study of the response to aerobic resistance exercises based on the type of foot in the child population

Estudio de la respuesta a ejercicios de resistencia de tipo aeróbico en función de la tipología del pie en la población infantil

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Keywords:

Pronation, children, pronated feet, aerobic exersice, resistance exercises.

Abstract

Introduction: The main objective of this work was to verify whether children with pronator feet obtain different results in aerobic resistance exercises compared to children who have a neutral foot typology according to the Foot Posture Index.

Patients and methods: This is an cross-sectional study of type observational and descriptive. One hundred and five children, aged between 10 and 12 years (10.46 ± 0.785) were recruited and divided into two groups: 63 formed the control group or neutral feet and 42 the case group or pronator feet. Of which 51 were boys and 54 girls. Five resistance exercises of aerobic type were selected to evaluate the motor performance in both types of feet, by means of a previously established circuit: jump rope with displacement, displacements at 8m distance, alternation legs in Swedish bench, mini-circuit in zig-zag, jump with feet together. Three series of exercises were carried out, where there was a 3-5 minutes rest period between each series. In each station the number of repetitions the child performed was calculated.

Results: The results obtained from our study indicate that both groups obtained very similar results in physical resistance tests ($p > 0.05$). The sample was homogeneous in terms of sex, age and BMI ($p > 0.05$) and with respect to the variable "times a week children perform sports" ($p > 0.05$).

Conclusions: These results suggest that children with neutral feet did not achieve better motor performance compared to children with pronated feet in the 5 resistance exercises evaluated in our study.

Palabras clave:

Pronación, niños, pies pronados, ejercicio aeróbico, ejercicio de resistencia.

Resumen

Introducción: El objetivo principal de este trabajo fue comprobar si los niños con pies pronados obtienen resultados diferentes en ejercicios de resistencia de tipo aeróbicos respecto a los niños que presentan una tipología de pies neutra según el Foot Posture Index.

Pacientes y métodos: Se trata de un estudio trasversal de tipo descriptivo y observacional. Ciento cinco niños, de edades comprendidas entre 10 y 12 años (10.46 ± 0.785), fueron reclutados y divididos en dos grupos: 63 formaron el grupo control o pies neutros y 42 el grupo casos o pies pronados; 51 fueron niños y 54 niñas. Se seleccionaron cinco ejercicios de resistencia de tipo aeróbico para evaluar el rendimiento motor en ambos tipos de pies, mediante un circuito previamente establecido: salto a la comba con desplazamiento, desplazamientos a 8 m de distancia, alternancia piernas en banco sueco, minicircuito en zigzag y salto con pies juntos. Se realizaron tres series de ejercicios, donde existió un periodo de descanso de 3-5 minutos entre cada serie. En cada estación se fue calculando el número de repeticiones que realizaba el niño.

Resultados: Los resultados obtenidos de nuestro estudio indicaron que ambos grupos obtuvieron resultados muy similares en las pruebas físicas de resistencia ($p > 0.05$). La muestra fue homogénea en cuanto a sexo, edad e IMC ($p > 0.05$) y respecto a la variable "veces a la semana que realizaban deporte los niños" ($p > 0.05$).

Conclusiones: Según los datos obtenidos en el presente estudio, no se han encontrado diferencias significativas en el rendimiento motor entre niños con pies pronadores y niños con pies neutros, en los 5 ejercicios de resistencia evaluados en el presente estudio, por lo que no se puede descartar la hipótesis nula de la investigación.

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INTRODUCTION

Regular physical activity is important when it comes to preventing sendentary habits that can trigger future health problems. This is why nowadays we try to encourage exercise from childhood. The foot, as the first link in the chain, is considered of special importance in sport and in any type of physical activity, bein the base of support for the rest of the body's movements.

Biomechanically, it is reasonable to consider that small alterations in the structure or alignment of the foot and ankle could influence the sporting performance of the activity carried out, affecting the rest of the body and conditioning the choice of subjects for a certain sport or simply for their daily life. Due to the impact that sport has nowadays on our society, the interest in knowing the biomechanical mechanisms that induce muscle fatigue, decreased performance and injury is an area that should be constantly studied by clinicians and researchers.

Some authors agree that in pronator feet there is an alteration of the axes of movement, which could favor the leg and foot muscles to tend to fatigue easily[1-6] being even greater in sports[4]. Controversy exits between different authors[7-17] and there is no consensus on whether the type of foot affects motor performance and whether pronator feet specifically presents some kind of disadvantage compared to neutral feet in sport. This is important since the prevention and improvement of biomechanical alterations in childhood stages by plantar supports would be a noteworthy point in this regard.

Although it is known that different types of feet can influence kinematics, plantar pressure[16,18,19], plantar footprint[9,13,15], foot posture[17] and electromyography (EMG)[20] of certain sports activities, according to the authors' knowledge, no studies have been carried out that report how resistance exercises could influence children aged 10-12 years with pronated feet and neutral feet, as defined by the Foot Posture Index (FPI-6)[21]. The main objective of this work was to verify whether children with pronated feet obtained different results in aerobic-type resistance exercises compared to children who presented a neutral feet type.

PATIENTS AND METHODS

According to the characteristics of this work, this is a cross-sectional, observational and descriptive study. For its performance, the work was submitted for evaluation by the research ethics committee of the Virgen Macarena-Virgen del Rocío University Hospitals, obtaining a favorable assessment.

Study population

Children in the study were enrolled in 5th and 6th grade of primary school (Spain educational system), from two educational centers in the town of Jimena de la Frontera, (Cádiz, Andalucía, Spain). The two educational centers are public and had adequate facilities, such as an outdoor sports court and an indoor room set up for sports activities.

Data collection was carried out during the years 2014, 2015 and 2016 always in the morning. Prior parents informed consent was obatined.

Children who participated in the study had to strictly comply with the established selection criteria. Those who presented a Body Mass Index (BMI) equivalent to normal weight, that is, a percentile between 5 and 85 according to the percentage of BMI with respect to age[22,23], and a type of pronated feet or neutral feet according to the FPI-6[21].

All those who were in orthopedic treatment at the time of the study, those who could not complete the established physical tests or had experienced some type of osteoarticular surgery, trauma or degenerative osteoarticular diseases in the feet or lower limbs (MMII) and those that presented each of their feet in a different categorization according to the FPI-6[21] we excluded.

Variables of study

Variables used in this research are listed below, differentiating between qualitative variables: sex, (with the category boy and girl) and quantitative variables: Age, quantified in years, BMI (weight/height), quantified in kg/m^2, Foot Posture Index, times a week that children performed sports and physical tests: jump rope with movement (3 series), 8 m distance displacements (3 series), alternating legs on Swedish bench (3 series), mini-circuit in zig-zag (3 series), jump with feet together (3 series).

Intervention

Data were extracted by a single examiner (M.A.G.B) in order to avoid possible interpersonal error. The protocol carried out always followed the same order that is expressed below.

Firstly, anthropometric measurements were taken using a weight and a height rod to calculate the subject's BMI, that determined the percentile the child was and whether or not it should be included in the study. Using the formula BMI = weight (kg)/height (m)^2. If the value obtained from the formula corresponded to a percentile between 3 and 90, equivalent to normal weight, the subject was included in the study.

Secondly, the posture of the foot was assessed using the FPI-6[21], to classify them into two groups, pronated feet or neutral feet, according to the type of feet. Those subjects with values from 0 to +5 (corresponding to neutral foot) were incorporated into the control group and subjects with values from +6 to +9 (pronated) and from +10 to +12 (highly pronated) were incorporated in the group cases or pronated feet.

Thirdly, child footwear type was assessed as it was important not to wear elements that would make them "pronator" or "supinator", with characteristics of a healthy shoe and suitable

Table I. Descriptive results of the 5 variables for the physical test in the Control and Case Groups.

		Jump Rope (number of jumps)	8m displacement (Repetitions)	Swedish bench (number of jumps)	Zig-zag circuit (Repetitions)	Jump with feet together (number of jumps)
Control Group	Mean ± SD	28.70 ± 8.59	9.30 ± 1.20	52.11 ± 12.45	3.40 ± 0.74	63.78 ± 10.41
	Min.	8	7	23	2	33
	Max.	48	14	83	5	100
Case Group	Mean ± SD	26.24 ± 7.50	9.02 ± 1.31	47.9 ± 12.67	3.36 ± 0.75	62.36 ± 9.25
	Min.	7	7	22	2	45
	Max.	41	12	72	5	87

SD: standar deviation.

for a sporting activity. Those who were not wearing it at the time of the study performed the physical tests on a different day. After that, children were asked how many times a week they played sports, recording it on our data collection sheet.

Sport activities carried out were aerobic-type resistance exercises. The exercises consisted of 6 positions where each child stayed 30 seconds. In each position the number of repetitions performed by the child was calculated. 3 series of exercises were performed where there was a rest period of 3-5 minutes between each series. The collaborator who counted the repetitions was blinded regarding the type of foot of the child and the researcher who classified the groups (M.A.G.B.) was different to the one who accounted for the physical evidence.

The positions carried out were: Gentle running, for starting the exercises with better physical fitness, jump rope with displacement, displacements touching lines at 8 m distance, alternating legs on the Swedish bench, mini-circuit in zig-zag and jump with the Feet together.

Statistical analysis

To perform the statistical analysis, the statistical package SPSS Statistics22 was used. For the descriptive analysis of the variables, the mean values, the standard deviation (S.D.), the minimum and the maximum have been calculated. The Kolmogorov-Smirnov test was performed to check if the data followed a normal distribution. As a result of this test, it was decided that the Mann-Whitney U test would be used for the comparisons of the variables jump rope with displacement, displacements at 8 meters of distances, zig-zag circuit and jump with feet together. For the Swedish bench leg alternation variables, the Students' T would be used for independent samples. It has been considered statistically significant as long as the value of P was less than 0.05.

RESULTS

The study sample consisted of 105 participants, of whom 51 were boys and 54 girls, aged between 10 and 12 years (10.46 ± 0.785). Sisty-three out of 105 children formed the control group or group of neutral feet, 35 were boys and 28 girls. The case group or group of pronated feet was formed by 42 children, where 16 were boys and 26 girls. The sample was homogeneous in terms of sex, age and BMI ($p > 0.05$) and with respect to the variable "times a week that children do sports" ($p = 0.105$).

Table II. Statistical significance of the physical tests.

Physical Tests	(P - value)
Jump Rope	0.171
8m displacement	0.239
Swedish Bench	0.095
Zig-zag circuit	0.825
Jump with feet together	0,332

At a descriptive level, mean values, the standard deviation and the maximum and minimum of the 5 variables belonging to the physical tests carried out in the study were expressed, for the case group and for the control group in Table I.

The central values of the three repetitions of the same physical test were compared to check if there were significant differences in the number of repetitions performed by the children in the neutral feet group with those in the pronated feet group. The results showed non-statistically significant values. That is, no differences were found in the results of physical tests between groups (Table II).

DISCUSSION

Results obtained from our study indicate that both groups obtained very similar results in the physical endurance tests. However, we have to recognize that there were descriptive differences in the values obtained in each physical tests between the case group and the control group. That is, children

with pronated feet obtained fewer repetitions in physical tests compared to children with neutral feet. Although the result was not statistically significant in any of the 5 tests carried out, in 2 of them (jump rope with displacement and Swedish bench jump), results were close to significance.

As mentioned in previous articles that evaluated the types of feet through various exercises, we observed that individuals were subjected to a combination of strength, endurance, speed and flexibility exercises, mostly obtaining non-significant results[7,8,10,12,24,25]. Strength, endurance, speed and flexibility are basic physical capacities that develop throughout the child's growth[26]. According to Mora[26], aerobic endurance is the physical ability to make an effort by having sufficient oxygen during all activity for the oxidation of energy substrates (glucose and fatty acids) that will be necessary for muscle contraction. The evolution of this physical-motor capacity is linked to the growth and transformations of the cardiovascular system. Thus, increasing the volume of the heart during this phase of childhood life will increase the maximum oxygen volume (Vo^2). The development of this capacity begins at 6 years of age and experiences its maximum progress at 10-11 years, remaining stable until 15 years[26]. In this case, we consider that 10-12 years was the optimal study age, since it would remain stable until 15 years.

It was difficult to compare our work with those found, since they all studied the performance of the different types of feet in different physical activities and motor tests, and we only included the physical endurance capacity. However, our findings are roughly in line with what most authors claim. Kaufman et al.[25] assessed whether foot type was an influencing factor in physical activity in 50 subjects with flat feet and 50 with neutral feet after performing a series of physical exercises for agility, balance and speed. Their results showed that physical performance in the two study groups was similar and did not depend on the morphology of the foot. Similarly, Arévalo in 2013[12] conducted a very similar study that included 187 individuals aged 10-12 years to study to look for if some type of foot (normal, hollow, flat) had better performance in motor tests of long jumps, triple jumps, balances and agility circuits. In his conclusions, he pointed out that the type of foot did not affect motor performance in these types of tests and no type of foot was better than another, with the exception of cavus feet that obtained better results.

Tudor et al. in 2009[10] carried out 4 groups depending on the degree of flattening of the arch and subjected them to a series of physical tests, jumping, speed, balance and others such as flexing the fingers and standing on tiptoe. They found no correlation between arch height and the 17 motor skills performed. Similarly, they stated that there was no disadvantage in sports performance after comparing the extreme foot groups (very high arches and very low arches). Kumala et al. in 2019[7], studied the differences in physical performance in athletes aged 14-17 years with flat feet and neutral feet using strength, balance and speed exercises. No differences were found in the physical performance of each of the tests in both groups. Authors such as Roohi et al.[8] subjected a group formed by pronated feet and another group by neutral feet to tests speed, agility, static and dynamic evaluations. They only found differences between groups regarding agility and static balance tests, not finding differences in speed and dynamic balance tests. Those results are difficult to compare with those of our study since we only include basic physical endurance capacity, unlike those which include several. However, Lin et al.[27] disagreed with the results of all these authors, as they claimed to have obtained worse scores in moderate and severe flat feet compared to neutral and cavus in different athletic tasks.

We consider necessary to clarify that one of the most obvious limitations that our study has refers to the sample studied, we could say that it was relatively small and not representative enough for the results to be more conclusive. This aspect is directly related to potency, results were probably negative due to the low power of the study. On the other hand, the limited information in studies that assess the different types of foot exclusively through resistance tests, could have influenced that the positions carried out or the established time intervals were not the most appropriate to obtain conclusive results.

In conclusion, the findings of the present study have not shown statistically significant differences in the motor performance of the children of the pronator feet group compared to the children of the neutral feet group, in the 5 aerobic-type resistance exercises evaluated in the research. However, descriptive differences have been observed between both groups, being repetitions lower in the pronator feet group. Although there was no significance in the 5 tests performed, the Swedish bench leg alteration exercises and rope jump were close to statistical significance in the present study.

CONFLICT OF INTERESTS

The authors declare that they have no relevant conflicts of interest in this article.

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