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Original Research

Effects of School Sports Spaces on Electromyography Activity of Lower Limb and Erector Spinae Muscles during Running in Students

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ABSTRACT

The aim of this study was to evaluate the effects of school sport spaces on electromyography activity of lower limb and erector spinae muscles during running in students. Fifteen students with an age range between 10 to 14 years from schools with suitable sport facilities and fifteen students with the same age range from schools with inappropriate sport spaces. A wireless electromyography system with 8 pairs of bipolar surface electrodes (sample rate: 2000 Hz) was used to record the electromyography activity of back and lower limb muscles during running. The results showed that during the loading response phase, median frequency of the tibialis anterior ($p=0.005$, $d=1.27$) and medial gastrocnemius ($p=0.021$, $d=0.93$) muscles in the suitable sport facilities group were higher than that the other group by 13.45% and 38.28%, respectively. Also, during the propulsion phase, median frequency of biceps femoris muscle in the suitable sport facilities group was higher than that the other group by 28.88% ($p=0.002$, $d=1.37$). In addition, during the loading response phase, amplitude of medial gastrocnemius ($p=0.024$, $d=0.84$) and erector spinae ($p=0.014$, $d=0.85$) muscles in the suitable sport facilities group were lower than other group by 35.55% and 43.29%, respectively. The results of this study showed that students in schools with suitable sport facilities have better performance of the lower limb and erector spinae muscles while running, which reduces the chance of injury during running.
Keywords: Electromyography, Frequency spectrum, Students, Running.

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Introduction

The safety and health of sports venues and spaces are one of the most essential issues for sports specialists, sports medicine, and community health officials (1-3). The existence of non-standard and worn-out barriers and equipment will undoubtedly cause physical harm to students (1). The most important factors that reduce the level of health and safety of sports spaces are the insufficient sport spaces, and the unhealthy conditions of the school environment and inappropriate sports space. Because students spend 5-7 hours a day, six days a week, and about nine months of their life in school, the possibility of injury may be affected by school faciliities. According to a previous research, boys and girls have a high level of interest in sports, but they are less interested in physical activity in physical education classes, so coaching and physical education alone cannot encourage students to play (4). Nevertheless, there is equipment and facilities that can be effective in students' sports performance; this requires an environment that paves the way for their expansion and interest (5). Since the optimal quality of physical education training depends on the right way of training and having the right sports space, having the desired sports space and how to create a space that fits the needs, requires identifying the components and functional situation, and examining the required spaces and facilities (6). Inadequate sport spaces cause students to avoid sports activities due to injury, which in turn leads to sedentary lifestyles. Running according to the facilities of children's schools is the most available aerobic activity that has a positive role in improving their physical fitness (7). The cyclical nature of running in non-standard spaces causes repetitive loading of the lower limbs, and as the activity continues, this load becomes even more intense (8). Meanwhile, the muscles involved during the activity are responsible for distributing these dynamic loads on the lower limbs. Electromyography (EMG) signals are a valuable approach to studying muscle contraction (9). The EMG signal is a biomedical signal that measures electrical currents generated in muscles during its contraction representing neuromuscular activities (10). The nervous system always controls the muscle activity (contraction/relaxation). Hence, the EMG signal is a complicated signal, which is controlled by the nervous system and is dependent on the anatomical and physiological properties of muscles (11). The main reason for the interest in EMG signal analysis is in clinical diagnosis and biomedical applications. The field of management and rehabilitation of motor disability is identified as one of the important application areas. The shapes and firing rates of motor Unit action potentials (MUAPs) in EMG signals provide an important source of information for the diagnosis of neuromuscular disorders (12).

Khani et al. (2014) reported that the use of footrests and rubber flooring are effective ways to reduce the injury of the lower limbs (13). Previous studies evaluated the muscle activities during walking and standing for long periods (14-16). However, the role of school facilities on activity of the lower limb muscles has not been evaluated scientifically. Given the importance of this issue, the aim of this study was to evaluate the effect of school sport spaces on electromyography activity of lower limb and erector spinae muscles during running in students.

Material and Methods

Participants

The present study was semi-experimental and laboratory. Using G * Power software, it was found that to achieve a statistical power of 0.8, effect size of 0.8, at significance level of 0.05, at least 15 samples was required. Fifteen students with an age range between 10 to 14 years were selected from schools with suitable sports facilities and fifteen boy students with the same age range from schools with unappropriate sports spaces.

Inclusion criteria included: lack of lower extremity pain in the past three months; lack of surgical history (in knee, spine, hip, and ankle) and age range between 10 to 14 years (17)

Exclusion criteria included: history of skeletal muscle dysfunction, history of arthritis, chronic arthritis infection or bone disease, low back pain, ligament injury, ligament remodeling, and muscle disorders.

Data collection

An electromyography system (DataLITE EMG, Biometrics Ltd) made in England was used to record muscle activities during running. Medical adhesive tape was used to fix electrodes and probes on the skin to minimize any motion artefact. EMG signals were sampled at 1000 Hz (band pass filtered 10-500 Hz; input impedance > 10 G Ohm; common mode-rejection ratio >110 dB) by a portable Wi-Fi transmission device.

The dominant limb was used to record data (18). Participants were instructed to refrain from any kind of physical training in the 24 h preceding the experiment and data collection, to ensure their ability to perform the trial in their best possible physical conditions. The running style was according to heel strike pattern. Running speed was self-selected. The children performed warm-up for 5 minutes before running protocol.

The position of the electrodes on each muscle was according to the SENIAM protocol. The electrodes were positioned on each muscle in the direction of the muscle fibers. Electrodes were placed on gastrocnemius medialis (GM), biceps femoris (BF), semitendinosus (ST), erector spinae (ES), tibialis anterior (TA), vastus medialis, vastus lateralis and rectus femoris muscles (19, 20). The median frequency and normalized amplitude (% maximum isometric voluntary contraction) of the electromyography signal was calculated during loading response and propulsion phases of running.

Figure 1: Electrodes positions in according to SENIAM recommendation

Statistical analysis

Data normalization was confirmed using the Spiro-Wilk test. The independent sample t-test was used for statistical analysis. All analyzes were performed at a significance level of 0.05 using SPSS software version 22.

Results

Data normalization was confirmed using the Spiro-Wilk test (p>0.05) (Table 1).

Table 1: Tests of normality

Phase	Muscle	Median frequency		Amplitude	
		Statistic	Sig.	Statistic	Sig.
Loading response phase	TA	0.948	0.614	0.966	0.860
	GC	0.964	0.841	0.928	0.361
	BF	0.913	0.235	0.938	0.470
	ST	0.970	0.913	0.977	0.970
	VM	0.956	0.719	0.959	0.770
	VL	0.938	0.477	0.896	0.142
	RF	0.900	0.158	0.934	0.421
	ES	0.887	0.108	0.919	0.280
Propulsion phase	TA	0.924	0.323	0.971	0.917
	GC	0.968	0.888	0.957	0.739
	BF	0.969	0.904	0.932	0.402
	ST	0.917	0.262	0.958	0.761
	VM	0.932	0.401	0.964	0.834
	VL	0.947	0.588	0.935	0.432
	RF	0.943	0.532	0.945	0.559
	ES	0.973	0.940	0.979	0.980

In the present study, 15 students in the school with suitable sport facilities and 15 Students were selected at school with unsuitable sport facilities (Table 2). There was no significant difference between the two groups in age, height, mass and body mass index (P <0.05) (Table 2).

Table 2: Average age, weight and height in two groups

Variable	Suitable sport facilities	Unsuitable sport facilities	P-value
Age (years)	12.73±1.09	12.13±1.50	0.223
Height (cm)	149.80±9.66	149.20±10.40	0.872
Weight (kg)	45.20±6.96	46.60±9.13	0.640
BMI (kg/m^2)	23.14±4.76	22.86±5.65	0.753

The results showed that during the loading response phase, median frequency of the tibialis anterior (p=0.005, d=1.27) and medial gastrocnemius (p=0.021, d=0.93) muscles in the suitable sport facilities group were higher than that the other group by 13.45% and 38.28%, respectively (Table 3). Also, during the propulsion phase, median frequency of biceps femoris muscle in the suitable sport facilities group was higher than that the other group by 28.88% (p=0.002, d=1.37) (Table 3).

Table 3: Between group comparison of the median frequency of lower limb and erector spinae muscles during running.

Phase	Muscle	Suitable Sport Facilities	Unsuitable Sport Facilities	Δ%	P-value
Loading response	TA	114.20±15.32	100.66±5.96	13.45	0.005*
	GC	105.73±23.54	76.46±39.13	38.28	0.021*
	BF	91.20±34.89	94.60±34.06	-3.59	0.789
	ST	57.80±17.92	72.86±32.40	-20.66	0.151
	VM	93.86±35.63	79.00±27.66	18.81	0.212
	VL	87.40±38.65	82.26±30.01	6.24	0.688
	RF	55.60±12.14	60.12±21.12	-7.51	0.324
	ES	78.40±23.57	79.86±52.72	-1.82	0.934
Propulsion	TA	96.93±18.08	87.23±26.56	11.12	0.218
	GC	90.66±43.82	87.40±43.82	3.72	0.839
	BF	102.93±10.38	79.86±23.35	28.88	0.002*
	ST	68.33±21.42	81.20±32.82	-15.84	0.216
	VM	88.06±30.35	94.13±36.65	-6.44	0.625
	VL	86.33±37.96	81.66±33.30	5.71	0.723
	RS	76.16±23.32	77.24±12.35	-1.39	0.920
	ER	69.53±23.04	68.86±29.92	0.97	0.946

The results showed that during the loading response phase, amplitude of medial gastrocnemius (p=0.034, d=0.84) and erector spinae (p=0.014, d=0.85) muscles in the suitable sport facilities group were lower than other group by 35.55% and 43.29%, respectively (Table 4).

Also, during the propulsion phase, amplitude of semitendinosus (p=0.043, d=0.86) and erector spinae (p=0.025, d=0.83) muscle in the suitable sport facilities group were lower than other group by 37.28% and 37.21%, respectively (Table 4).

Table 4: Between group comparison of the electromyography amplitude (% maximum isometric voluntary contraction) of lower limb and erector spinae muscles during running

Muscle	Muscle	suitable sport facilities	unsuitable sport facilities	Δ%	P-value
Loading response	TA	42.48±23.43	40.19±22.98	5.69	0.789
	GC	38.75±18.26	60.13±32.26	-35.55	0.034*
	BF	34.81±13.70	45.76±20.85	-23.92	0.102
	ST	24.61±12.31	29.68±21.25	-17.08	0.431
	VM	54.00±17.79	44.52±23.38	21.29	0.222
	VL	30.43±16.96	36.43±10.23	-16.46	0.515
	RF	22.25±16.44	23.88±11.46	-6.82	0.763
	ES	28.43±19.91	50.14±25.10	-43.29	0.014*
Propulsion	TA	29.24±19.98	40.90±24.91	-28.50	0.168
	GC	40.36±22.92	53.95±32.48	-25.18	0.201
	BF	39.85±23.09	49.34±23.80	-19.23	0.277
	ST	20.99±7.97	33.47±20.75	-37.28	0.043*
	VM	40.44±21.54	53.56±22.52	-24.49	0.114
	VL	23.23±11.22	24.25±10.23	-4.25	0.894
	RF	23.72±7.52	31.26±12.35	-1.39	0.365
	ES	33.36±16.72	53.13±27.27	-37.21	0.025*

Discussion

The aim of this study was to evaluate the effects of school sport spaces on electromyography activity of lower limb and erector spinae muscles during running in students.
The results showed that during the loading response phase, median frequency of the tibialis anterior and medial gastrocnemius muscles in the suitable sport facilities group were higher than that the other group. Also, loading response phase, amplitude of medial gastrocnemius muscles in the suitable sport facilities group were lower than other group. When running, from the heel contact to the stance step, the work done by tibialis anterior muscle is negative. Negative muscle work reduces load in the lower extremities (21, 22). In addition, the absorbed energy can help keep the moving energy (21-24). Since one of the main differences between the human body and rigid bodies is in the ability to adapt and regulate performance in different conditions, it is normal to observe different human behavior when moving on surfaces with different stiffnes (21-24). This change in a person's behavior is to compensate for changes in surface area in order to maintain the natural pattern of movement of the center of mass (25). Previous studies have shown that increasing medial gastrocnemius activity and tibialis anterior at during the loading response phase can prevent possible foot pronation (26-28). Given the above, it can be said with caution that students in schools with unsuitable sport facilities are at risk of developing lower limb injuries. However, furter study waranted.
Also, during the propulsion phase, median frequency of biceps femoris muscle in the suitable sport facilities group was higher than that the other group.

The findngs showed that during the loading response phase, amplitude of medial gastrocnemius and erector spinae muscles in the suitable sport facilities group were lower than other group. Also, during the propulsion phase, amplitude of semitendinosus and erector spinae muscle in the suitable sport facilities group were lower than other group. Unsuitable sport facilities increase the forces on the lower limbs and impair the activity of the muscles during running.

The present study has some limitations such as lack of female gender in the statistical sample and self-selection speed while running. On the other hand, lack of recording kinematics and kinetics of lower limbs and trunk was another limitation of this study.

Conclusion: The results of this study showed that students in schools with suitable sport facilities have better performance of the lower limb and erector spinae muscles while running, which reduces the chance of injury during running.

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چکیده فارسی

تاثیر فضاهای ورزشی در مدارس بر طیف فرکانس فعالیت الکترومیوگرافی عضلات اندام تحتانی و راست کننده ستون مهره ای در دانش آموزان طی دویدن

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فضاهای ورزشی نامناسب می تواند احتمالا باعث تغییر در فعال شدن عضلات درگیر هنگام دویدن شود. هدف از پژوهش حاضر بررسی تاثیر فضاهای ورزشی در مدارس بر طیف فرکانس فعالیت الکترومایوگرافی عضلات اندام تحتانی و راست کننده ستون مهره ای در دانش آموزان طی دویدن می باشد. ۱۵ نفر دانش آموز با دامنه سنی ۱۰ تا ۱۴ سال از مدارس دارای فضای ورزشی مناسب و ۱۵ نفر با همین دامنه سنی از مدارس فاقد فضای ورزشی مناسب انتخاب شدند. از یک سیستم الکترومایوگرافی بدون سیم با ۸ جفت الکترود سطحی دو قطبی برای ثبت فعالیت الکترومایوگرافی (نرخ نمونه برداری: ۲۰۰۰ هرتز) عضلات ناحیه کمر و اندام تحتانی طی دویدن استفاده شد.
نتایج نشان داد طی فاز پاسخ بارگیری میانه فرکانس عضله درشت نئی قدامی (p =۰/۰۰۵ وd= ۱/۲۷) و عضله دوقلو داخلی (p =۰/۰۲۱ وd= ۰/۹۳) در گروه فضاهای ورزشی مناسب در مقایسه با فضاهای ورزشی نامناسب به ترتیب ۱۳/۴۵ و ۳۸/۲۸ درصد بیشتر بوده است. همچنین طی فاز پیش روی میانه فرکانس دوسرانی در گروه فضاهای ورزشی مناسب در مقایسه با فضاهای ورزشی نامناسب ۲۸/۸۸ بیشتر بوده است (p =۰/۰۰۲ وd= ۱/۳۷). به علاوه دامنه فعالیت عضله دوقلوی داخلی(p =۰/۰۳۴ وd= ۰/۸۴) و راست کننده ستون فقرات(p =۰/۰۱۴ وd= ۰/۸۵). طی فاز پاسخ بارگیری در گروه فضاهای ورزشی مناسب در مقایسه با فضاهای ورزشی نامناسب به ترتیب ۳۵/۵۵ و ۴۳/۲۹ درصد کمتر بوده است. می توان نتیجه گرفت دانش آموزانی که در مدرسه با فضاهای ورزشی مناسب هستند از عملکرد بهتر عضلات اندام تحتانی و راست کننده ی ستون فقرات هنگام دویدن برخوردار می باشند که این امر احتمال آسیب را طی دویدن کاهش می دهد.
واژه‌های کلیدی: الکترومایوگرافی، میانه فرکانس، دانش آموزان، دویدن