fizjoterapia polska

POLISH JOURNAL OF PHYSIOTHERAPY

OFICJALNE PISMO POLSKIEGO TOWARZYSTWA FIZJOTERAPII

THE OFFICIAL JOURNAL OF THE POLISH SOCIETY OF PHYSIOTHERAPY

NR 1/2022 (22) DWUMIESIĘCZNIK ISSN 1642-0136

The impact of high body weight on children's aerobic capacity in the primary school age

Wpływ nadmiernej masy ciała na wydolność fizyczną dzieci w młodszym wieku szkolnym

Physical activity and patients with frailty syndrome

Aktywność fizyczna u pacjentów z zespołem kruchości

mindray
healthcare within reach

ULTRASONOGRAFIA W FIZJOTERAPII

Autoryzowani dystrybutorzy

Mar-Med

+48 22 853 14 11

info@mar-med.pl

Ado-Med

+48 32 770 68 29

adomed@adomed.pl

MAR-MED
OD 1995 ROKU

ADO-MED®
APARATURA MEDYCZNA

Foot Medical

Fizjoterapeuto!

Problem zaczyna się u podstawy, czyli od stóp.

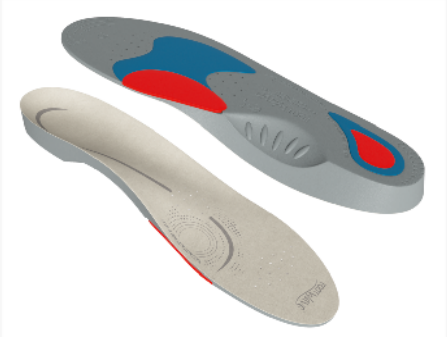
Leczenie
fizjoterapeutyczne bez uwzględnienia **zdrowia stóp** i **prawidłowej postawy** niesie ze sobą poważne ryzyko niepożądanych konsekwencji biomechanicznych.

Zaufaj FootMedical!

Jesteśmy producentem, dystrybutorem oraz ośrodkiem szkoleniowym specjalizującym się w biomechanice kończyny dolnej i jej zaopatrzeniu, szczególnie w dynamiczne wkładki ortopedyczne.

PRODUKT MEDYCZNY WSPARCIE I ODCIĄŻENIE

CERTYFIKOWANE WYROBY MEDYCZNE O POTWIERDZONEJ NAUKOWO SKUTECZNOŚCI



FootWave™

Dynamiczne wkładki ortopedyczne dedykowane najczęstszym schorzeniom stóp (haluksy, płaskostopie, ostroga piętowa, itp.). Dostępne również dla dzieci!

www.footwave.pl

Vasyli Medical

Wkładki ortopedyczne indywidualnie dopasowywane do stopy pacjenta poprzez termoformowanie i precyzyjne kliny oraz peloty korekcyjne.

www.vasylimedical.pl

Digitsole Pro

Bezprzewodowe wkładki diagnostyczne badające chód i bieg pacjenta w całym cyklu (również fazie przenoszenia i lotu!), w naturalnych warunkach poruszania się, oparte o sztuczną inteligencję w chmurze.

www.digitsole.pl

+48 506 310 411
biuro@footmedical.pl
zamowienia@footmedical.pl
footmedical.pl/kontakt

www.footmedical.pl

FootMedical
Specjalistyczne zaopatrzenie ortotyczne
ul. Chwaszczyńska 170C / 24
81-571 GDYNIA

NOWOŚĆ W OFERCIE

ASTAR.

PhysioGo.Lite SONO

NIEWIELKIE URZĄDZENIE
EFEKTYWNA **TERAPIA ULTRADŹWIĘKOWA**

Zaawansowana technologia firmy Astar to gwarancja niezawodności i precyzyjności parametrów. Urządzenie, dzięki gotowym programom terapeutycznym, pomaga osiągać fizjoterapeucie możliwie najlepsze efekty działania fal ultradźwiękowych.

Głowica SnG to bezobsługowe akcesorium o dużej powierzchni czoła (17,3 cm^2 lub 34,5 cm^2 w zależności od wybranego trybu działania). Znajduje zastosowanie w klasycznej terapii ultradźwiękami, fonoferezie, terapii LIPUS i zabiegach skojarzonych (w połączeniu z elektroterapią).

wsparcie merytoryczne
www.fizjotechnologia.com

ul. Świt 33
43-382 Bielsko-Biała

t +48 33 829 24 40
astarmed@astar.eu

www.astar.pl

POLSKI PRODUKT WYBIERASZ I WSPIERASZ

www.actabalneologica.pl

Acta Balneologica
jest naukowym czasopismem
Polskiego Towarzystwa Balneologii
i Medycyny Fizykalnej.
Ukazuje się od 1905 roku.

Na łamach kwartalnika
publikowane są recenzowane
prace z zakresu
balneologii, bioklimatologii,
balneochemii, hydrogeologii
i medycyny fizykalnej
– fizjoterapii, krioterapii,
kinezyterapii, presoterapii,
a także rehabilitacji.

Ze względu na poruszaną tematykę
jest wyjątkowym czasopismem
nie tylko w skali kraju,
ale i Europy.

INDEXED IN
EMERGING SOURCES CITATION INDEX
THOMSON REUTERS

20 PUNKTÓW MEIN

Prenumerata roczna kosztuje 150 zł.
Dla członków PTBiMF obowiązuje cena obniżona - 60 zł.
Koszty wysyłki na terenie kraju wliczone w cenę prenumeraty.
Ceny zawierają 5% VAT.

Zamówienia prenumeraty i pytania prosimy kierować na adres:

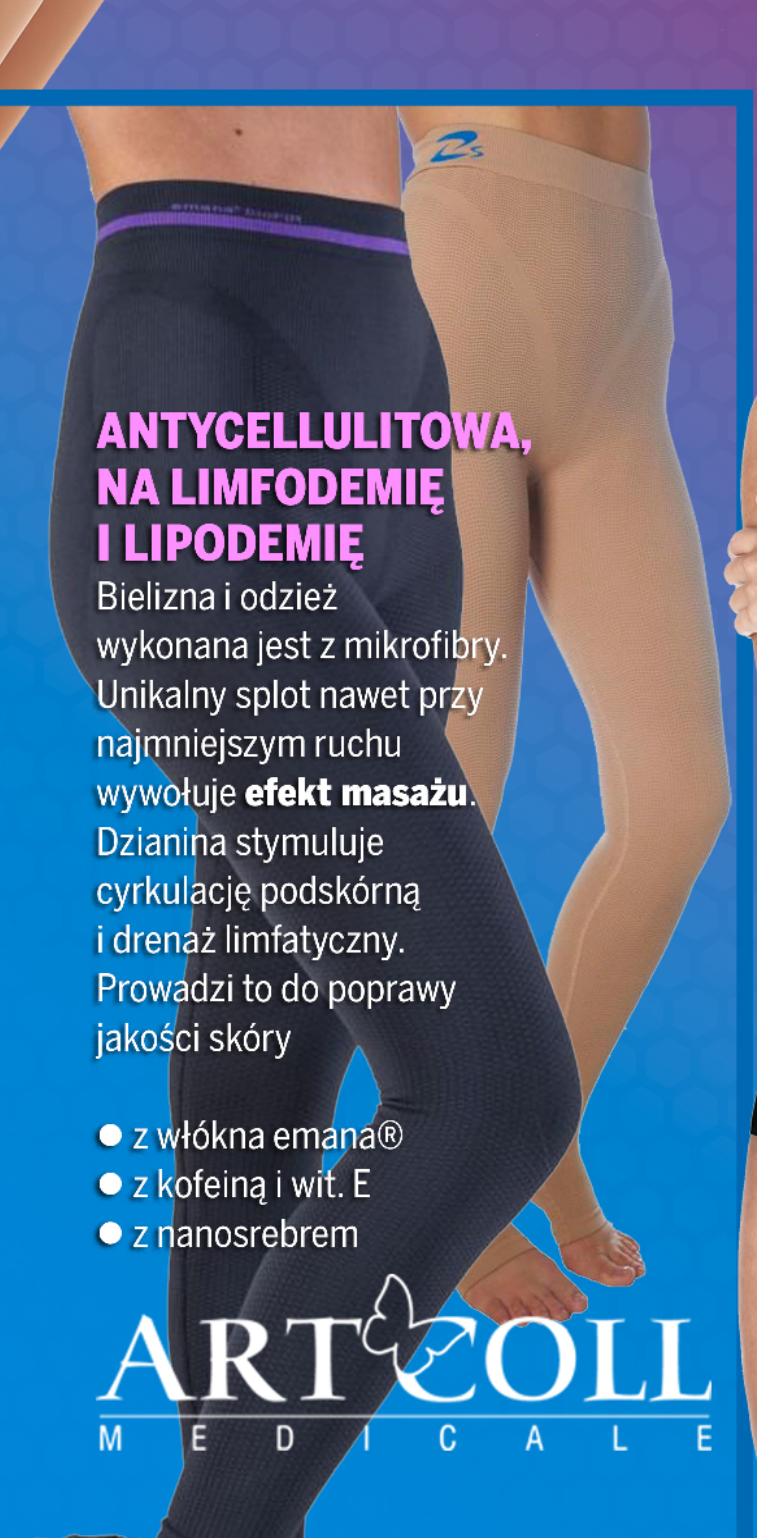
prenumerata@wydawnictwo-aluna.pl
Wydawnictwo ALUNA
Z.M.Przesmyckiego 29
05-510 Konstancin-Jeziorna
tel. 22 245 10 55 w godz. 9-15

FUNKCYJNA **BIELIZNA LECZNICZA**

PRZECIWŻYLAKOWA

Przeciwżylakowe wyroby pończosznicze włoskich producentów, bardzo skuteczne i niezwykle eleganckie. Dostępne **w I, II oraz III klasie kompresji** w wielu modelach, w różnym stopniu przezroczystości (m. in. wyjątkowo przezroczyste w II kl. ucisku), w szerokiej gamie kolorystycznej, w różnych wersjach długości, z palcami zamkniętymi lub otwartymi

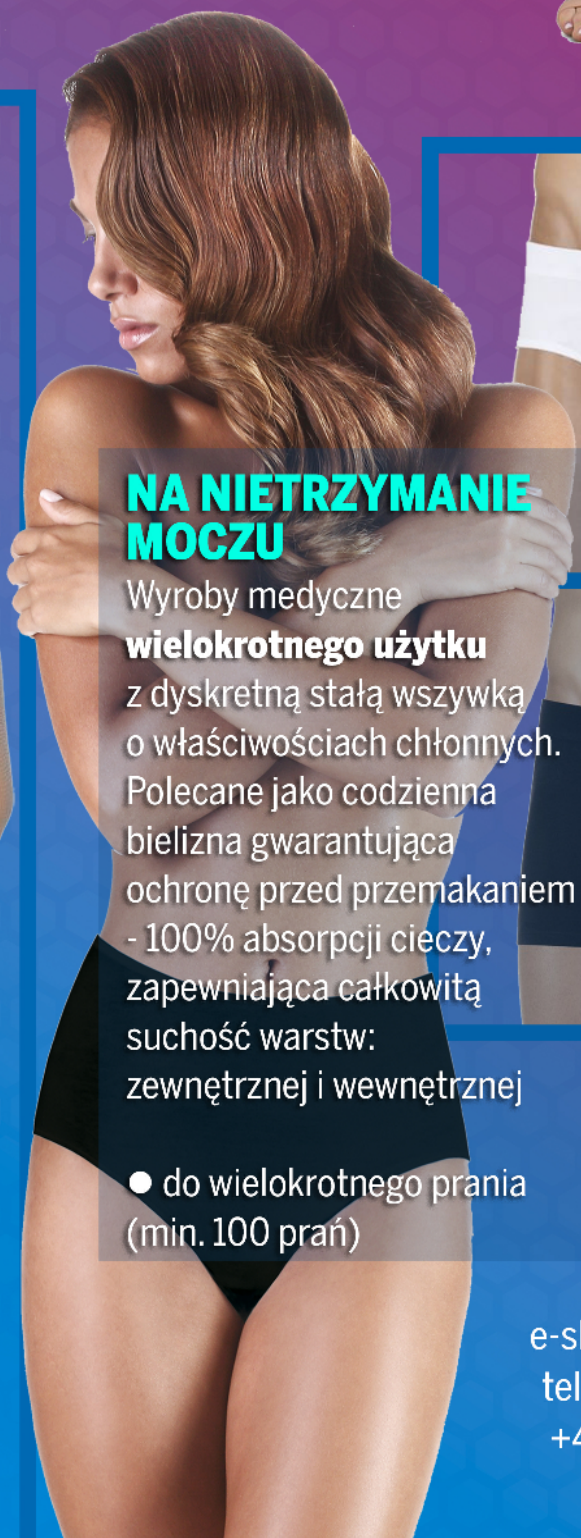
- podkolanówki
- pończochy
- leggingsy
- rajstopy
- rękawy kompresyjne



ANTYCELLULITOWA, NA LIMFODEMIĘ I LIPODEMIĘ

Bielizna i odzież wykonana jest z mikrofibry. Unikalny splot nawet przy najmniejszym ruchu wywołuje **efekt masażu**. Dzianina stymuluje cyrkulację podskórną i drenaż limfatyczny. Prowadzi to do poprawy jakości skóry

- z włókna emana®
- z kofeiną i wit. E
- z nanosrebrem



NA NIETRZYMANIE MOCZU

Wyroby medyczne **wielokrotnego użytku** z dyskretną stałą wszywką o właściwościach chłonnych. Polecane jako codzienna bielizna gwarantująca ochronę przed przemakaniem - 100% absorpcji cieczy, zapewniająca całkowitą suchość warstw: zewnętrznej i wewnętrznej

- do wielokrotnego prania (min. 100 prań)

ARTCOLL MEDICALE

artcoll.pl
e-sklep@artcoll.pl
tel. 22 720 35 96
+48 510 160 100

TYLMED ©

Polski producent MASAŻERÓW do stóp i ciała

infolinia: **500 238 037**

www.tylmed.pl

SwiatLasek.pl
WYJĄTKOWE LASKI

Najlepsze laski do chodzenia

Zamów on-line na: **www.swiatlasek.pl**
Wszelkie informacje pod numerem: **730 101 101**

Dr. Comfort®

Nowy wymiar wygody.

Obuwie profilaktyczno-zdrowotne o atrakcyjnym wzornictwie

NAGRODA POLSKIEGO TOWARZYSTWA REHABILITACJI

ACCEPTED
AMERICAN PODIATRIC MEDICAL ASSOCIATION

APROBATA AMERYKAŃSKIEGO MEDYCZNEGO STOWARZYSZENIA PODIATRYCZNEGO

CE WYRÓB MEDYCZNY

Miękki, wyścielany kołnierz cholewki
Minimalizuje podrażnienia

Stabilny, wzmocniony i wyścielany zapiętek
Zapewnia silniejsze wsparcie łuku podłużnego stopy

Wyścielany język
Zmniejsza tarcie i ulepsza dopasowanie

Lekka konstrukcja
Zmniejsza codzienne zmęczenie

Antypoślizgowa, wytrzymała podeszwa o lekkiej konstrukcji
Zwiększa przyczepność, amortyzuje i odciąża stopy

Zwiększona szerokość i głębokość w obrębie palców i przodostopia
Minimalizuje ucisk i zapobiega urazom

Wysoka jakkość materiałów - oddychające siatki i naturalne skóry
Dostosowują się do stopy, utrzymują je w suchości i zapobiegają przegrzewaniu

Ochronna przestrzeń na palce - brak szwów w rejonie przodostopia
Minimalizuje możliwość zranień

Trzy rozmiary szerokości

Podwyższona tęgość

Zwiększona przestrzeń na palce

WSKAZANIA

• haluksy • wkładki specjalistyczne • palce młotkowate, szponiaste • cukrzyca (stopa cukrzycowa) • reumatoidalne zapalenie stawów • bóle pięty i podeszwy stopy (zapalenie rozcięgna podeszwowego - ostroga piętowa) • płaskostopie (stopa poprzecznie płaska) • bóle pleców • wysokie podbicie • praca stojąca • nerwiak Mortona • obrzęk limfatyczny • opatrunki • ortezy i bandaże • obrzęki • modzele • protezy • odciski • urazy wpływające na ścięgna, mięśnie i kości (np. ścięgno Achillesa) • wrastające paznokcie

KALMED
Iwona Renz, Poznań

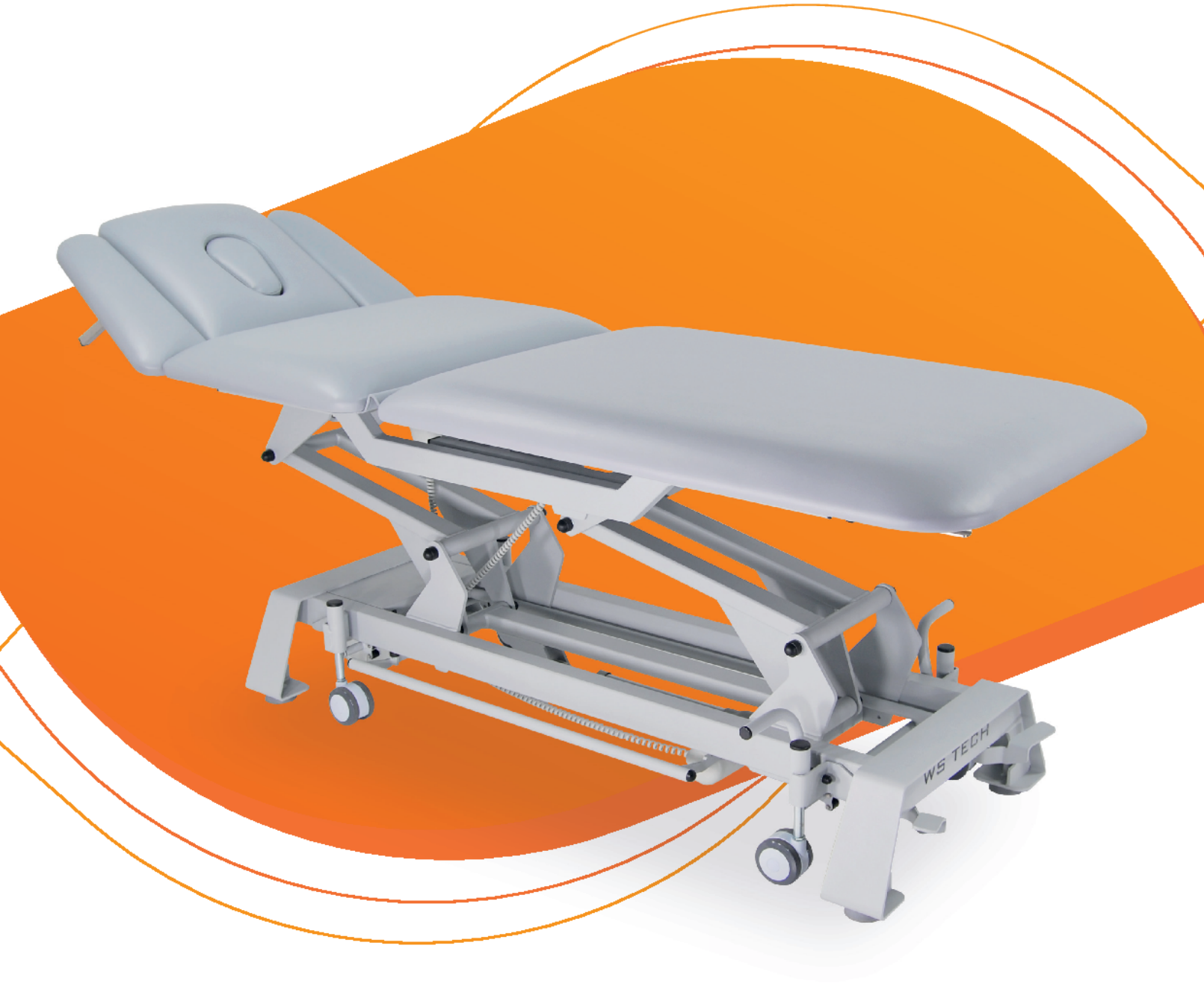
ul. Wilczak 3
61-623 Poznań
tel. 61 828 06 86
fax. 61 828 06 87
kom. 601 640 223, 601 647 877
e-mail: kalmed@kalmed.com.pl
www.kalmed.com.pl

www.butydlazdrowia.pl

www.dr-comfort.pl

WS TECH

Producent **sprzętu do rehabilitacji i masażu**
oraz **wyposażenia gabinetów medycznych**



WS TECH S.C.
ul. Okulickiego 43
38-500 Sanok

www.wstech.eu
biuro@wstech.eu

ZADZWOŃ
13 464 44 49

ZAMÓW ON-LINE
sklep.wstech.eu

REHA TRADE SHOW 3

14.04.2022 | PGE NARODOWY, WARSZAWA

TARGI I KONFERENCJA BRANŻY REHABILITACYJNEJ

- STREFA WYSTAWIENNICZA
- PONAD 60 FIRM Z BRANŻY REHABILITACYJNEJ
- 15 SEKTORÓW WYSTAWCÓW
- KONFERENCJA EDUKACYJNA
- WARSZTATY SPECJALISTYCZNE
- BUSINESS MATCHING

1 DZIEŃ BIZNESOWYCH SPOTKAŃ | PRESTIŻOWA LOKALIZACJA | 3 EDYCJA WYDARZENIA

WIĘCEJ INFORMACJI
WWW.REHATRADE.PL

ZŁOTY SPONSOR: NORAX medical

PARTNER STRATEGICZNY: Technomex

PARTNER MEDIALNY: REHA Biznes.pl

KALMED
Iwona Renz, Poznań

ARTROMOT®
WYŁĄCZNY PRZEDSTAWICIEL
WWW.KALMED.COM.PL

DJO GLOBAL

SPRZEDAŻ I WYPOŻYCZALNIA ZMOTORYZOWANYCH SZYN CPM ARTROMOT®

Nowoczesna rehabilitacja CPM stawu kolanowego, biodrowego, łokciowego, barkowego, skokowego, nadgarstka oraz stawów palców dłoni i kciuka.

ARTROMOT-K1 ARTROMOT-SP3 ARTROMOT-S3 ARTROMOT-E2

ARTROMOT-H

ARTROMOT-F

ARTROSTIM FOCUS PLUS

Najnowsze konstrukcje ARTROMOT zapewniają ruch bierny stawów w zgodzie z koncepcją PNF (Proprioceptive Neuromuscular Facilitation).

KALMED Iwona Renz
ul. Wilczak 3
61-623 Poznań
www.kalmed.com.pl

tel. 61 828 06 86
faks 61 828 06 87
kom. 601 64 02 23, 601 647 877
kalmed@kalmed.com.pl

Serwis i całodobowa pomoc techniczna:
tel. 501 483 637
service@kalmed.com.pl

mindray
healthcare within reach

ULTRASONOGRAFIA

W FIZJOTERAPII

Autoryzowani dystrybutorzy

Mar-Med

+48 22 853 14 11

info@mar-med.pl

Ado-Med

+48 32 770 68 29

adomed@adomed.pl

MAR-MED
OD 1995 ROKU

ADO-MED®
APARATURA MEDYCZNA

EiE OTWOCK

PRODUCENT NOWOCZESNEJ FIZYKOTERAPII

Jesteśmy z Wami od 1986r.

Elektroterapia · Laseroterapia
Magnetoterapia · Ultradźwięki
Suche kąpiele CO_2

SKANER LASEROWY
nowej generacji

Sprawdź naszą ofertę na
www.eie.com.pl

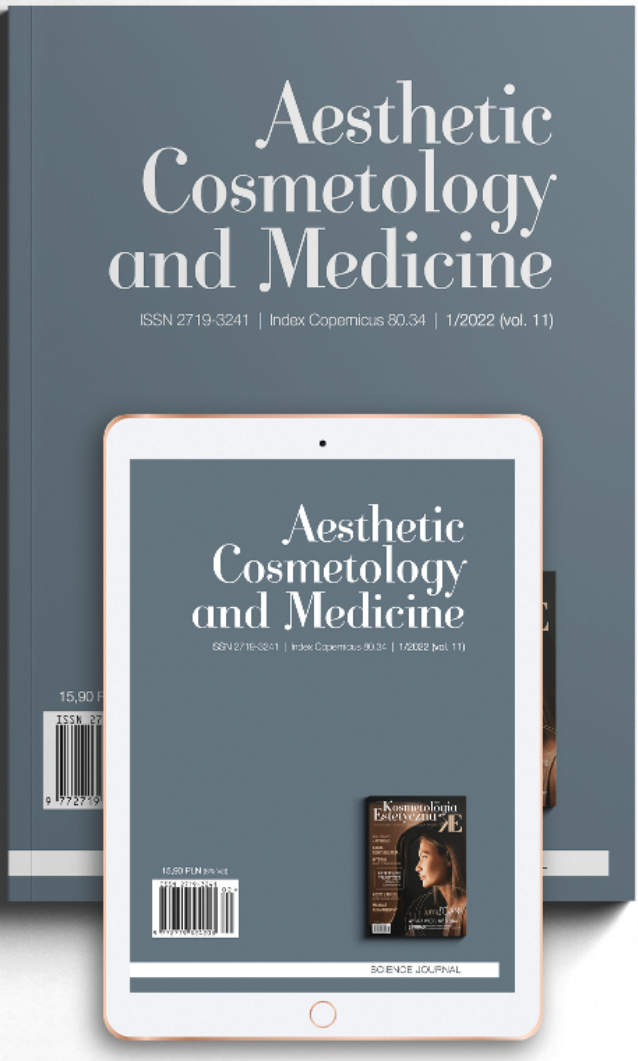
Elektronika i Elektromedycyna Sp.J.
05-402 OTWOCK, ul. Zaciszna 2
tel./faks (22) 779 42 84, tel. (22) 710 08 39
malew@eie.com.pl, www.eie.com.pl

Choose your version

aestheticcosmetology.com

Wybierz wersję dla siebie

kosmetologiaestetyczna.com



AC&M

Aesthetic Cosmetology and Medicine

KE

Kosmetologia Estetyczna

Reha INNOVATIONS

13-14.05.2022,
Kraków

Fizjoterapia

Nowoczesna diagnostyka

Odnowa biologiczna

Zeskanuj kod

i kup bilet na targi!

Sprawdź także:

Reha AKADEMIA INNOVATIONS

Bezpłatne webinaria, podcasty, wykłady otwarte oraz certyfikowane warsztaty z ekspertami.

www.rehainnovations.pl

Targi w Krakowie

"ORT" Butterfly®
Biomagnetic System

Rok założenia firmy 1996
www.butterfly-mag.com
tel. 85 743 22 21
kom. **603 299 035**

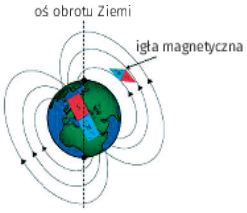
BIOMAGNETOTERAPIA W WYROBACH MEDYCZNYCH „ORT BUTTERFLY"

- BEZ BÓLU, STRESU I BEZ TABLETEK!
- LECZYSZ SIĘ NATURALNIE
- ŚPIĄC, PRACUJĄC, WYPOCZYWAJĄC...
- USUWASZ BÓL I JEGO PRZYCZYNĘ!
- TERAPIA STARA JAK ŚWIAT!
- SPRAWDZA SIĘ I DAJE RADĘ W NIERÓWNEJ WALCE Z PANDEMIĄ – COVID 19!

REGULARNA BIOSTYMULACJA MAGNETYCZNA!

Ogromny potencjał Natury w zwalczaniu smogu energetycznego i autooksydacji, będącej główną przyczyną wszystkich chorób cywilizacyjnych! **Najstarsza Terapia Świata** wspomagająca każdą formę leczenia! Uważa się do dziś, że bez niej nie da się wyleczyć żadnej choroby do końca! **Naturalna Terapia Magnetyczna** Twoje Zdrowie, Twoja Uroda, Odporność i Sprawność do późnej starości! **Wypróbuj** – gdy zawiodły już inne terapie!

Biomagnetoterapia inicjuje ożywienie komórkowe, oczyszcza i „odmładza" krew, podnosząc witalność całego organizmu, który uruchamia intuicyjne procesy obronne, znosząc dyskomfort powodowany bólem, urazem lub stresem, bez konieczności ostrej dawki leków chemicznych...



ZŁOTE LOGO
Międzynarodowych Targów
Rehabilitacja
Łódź IX/2007

DLACZEGO CHORUJEMY?
Natężenie sztucznych pól elektromagnetycznych zwiększyło się 100 tys. razy! Naturalne pole magnetyczne Ziemi zmniejszyło swą moc o połowę!

"ORT" Butterfly®
Biomagnetic System

BIOMAGNETYZM - *jako antidotum; jedyne i absolutne, na cancerogenną ekspansję „smogu energetycznego"!*

Jestem osobistym królikiem doświadczalnym! I żyję – realizując 25 lat wciąż nowe i śmielsze pomysły w wykorzystaniu tej **boskiej energii** naturalnych magnesów! Dzięki nim pokonuję dziś niezliczone przeszkody i przeciwności losu z nieznaną mi przedtem energią i determinacją! To moja pasja! I przeznaczenie!

Najnowsza opinia klienta:

Komentarz ten jest moim osobistym świadectwem zadowolenia z produktów biomagnetycznych „Ort Butterfly", których używam od 20. lat! Zastanawiam się, zwłaszcza nad fenomenem poduszki (określenie nie jest przypadkowe) zwyczajnie; nie wyobrażam sobie snu i wypoczynku bez magnetycznej „Ort Butterfly" – pod głową! Jej ergonomiczny, przyjazny dla głowy i szyi kształt sprawia, że wysypiam się „po królewsku". Zabieram ją również ze sobą w bliższe i dalsze podróże! Czyż gdyby była to zwyczajna poduszka, fundowałbym sobie dodatkowy bagaż? Wychwalam więc ją od zarania, polecam i rekomenduję, bo jest tego warta! Bez niej nie wyobrażam sobie prawdziwie relaksacyjnego snu i błogiego, kojącego wyczpoczynku! Dziękuję, że ją Pani stworzyła!

J. Szw. Działdowo (maj 2020)

PS *Poduszki „Ort Butterfly" to prawdziwe arcydziełka robione z wyczuciem i sercem... jak rzeźby Michała Anioła... Polecam wszystkim!*

Zapraszamy do zapoznania się z opiniami użytkowników i ekspertów jakie pojawiły się na przestrzeni ostatnich 10 lat: www.butterfly-mag.com → opinie klientów

elecpol

jednoosobowe lub dwuosobowe
kriokomory do terapii ogólnoustrojowej

icelab
VIP | VIP+

URZĄDZENIA DO REHABILITACJI, KRIOTERAPII, KINEZYTERAPII, FIZYKOTERAPII, HYDROTERAPII

elecpol ul.Łużycka 34a, 61-614 Poznań, 61 825 60 50, biuro@elecpol.pl, www.elecpol.pl

hydrosun® gymna Zimmer MedizinSysteme UNBESCHEIDEN Baden-Baden HYDRO THERAPIE®

W trosce o Seniora...

Naturalne Środki Czystości

PIELĘGNACJA / PROFESJONALIZM / ŚWIADOMOŚĆ
WSPARCIE / SZACUNEK

OVER CLEAN

www.over-clean.pl

fizjoterapia polska
nr 1/2022 (22)

Assessment of changes in the electrical activity of muscles in classic squat with a barbell in powerlifting athletes and people training Crossfit

Ocena zmian aktywności elektrycznej mięśni w przysiadzie klasycznym ze sztangą u zawodników trójboju siłowego i osób trenujących Crossfit

Bartosz Ruta[1(A,C,D,E)], Wojciech Walczak[2(A,B,D,E)]. Kamila Pasternak-Mnich[3(C,E,F)], Krzysztof Bortnik[4(A,D,E,G)]

[1]Medical Spa & Wellness Sp.zo.o., Gostynin / Medical Spa & Wellness Sp.zo.o., Gostynin, Poland
[2]Rehabilitacja Wojciech Walczak, Tarnobrzeg / Wojciech Walczak Rehabilitation, Tarnobrzeg, Poland
[3]Klinika Rehabilitacji Medycznej Uniwersytetu Medycznegow Łodzi / Department of Medical Rehabilitation, Medical University of Lodz, Poland
[4]Centrum Sportu Uniwersytetu Medycznego w Łodzi / Center of Sport, Medical University of Lodz, Poland

Abstract

Aim. Assessment of the degree of muscle involvement during a squat with a barbell in powerlifters and Crossfit trainers using surface electromyography (sEMG).

Material and methods. The study included two groups of 30 people exercising Crossfit and powerlifting, with an average age of 24 ± 2.8 years. Inclusion criteria: male gender, age range-22 to 28 years and a minimum of two years of training experience. Muscle tension measurements were made using the EMG FREEEMG300 electromyograph, in accordance with the SENIAM guidelines. The study consisted of a total of twelve repetitions of squats with a barbell, in two series of frontsquat and backsquat techniques.

Results. The mean and mean maximum muscle tone, each time statistically significant differences were noted - in the Crossfit group it was higher than in powerlifting.

Conclusions. The involvement of muscles during the squat with the bar and with the load equal to the body weight, performed using the "back squad" and "front squat" techniques is significantly higher in competitors training Crossfit. The analysis of the subjective assessment of difficulties in performing the exercises showed that the level of difficulty depends on the technique of performing the exercises. Reported difficulties of exercises - 50% of crossfiters using the "back squat" technique and 100% of powerlifters using the "front squat" technique.

Key words:

powerlifting, crossfit, muscle tone, sEMG

Streszczenie

Cel pracy. Ocena stopnia zaangażowania mięśni podczas przysiadu ze sztangą u zawodników trójboju siłowego iosób trenujących Crossfit z wykorzystaniem powierzchniowej elektromiografii (sEMG).

Materiał i metody. Badaniem objęto dwie 30-osobowe grupy ćwiczących Crossfit oraz trójbój siłowy, o średniej wieku 24 ± 2,8 lat. Kryteriami włączenia były: płeć męska, przedział wiekowy od 22 do 28 lat oraz minimum dwa lata doświadczenia treningowego. Pomiary napięcia mięśniowego wykonano z wykorzystaniem elektromiografu EMG FREEEMG 300, zgodnie z wytycznymi SENIAM. Badanie polegało na łącznym wykonaniu dwunastu powtórzeń przysiadów ze sztangą, w dwóch seriach technikami „front squat" i „back squat".

Wyniki. Średnie oraz średnie maksymalne napięcie mięśniowe każdorazowo, kiedy odnotowano statystycznie istotne różnice, w grupie Crossfit było wyższe niż u uprawiających trójbój siłowy.

Wnioski. Zaangażowanie mięśni podczas przysiadu z gryfem oraz z obciążeniem równym masie ciała, wykonywanego techniką „back squat' i „front squat" jest istotnie wyższe u zawodników trenujących Crossfit. Analiza subiektywnej oceny trudności w wykonywaniu ćwiczeń wykazała, ze poziom trudności jest zależny od techniki wykonywania ćwiczeń. Zgłaszane trudności ćwiczeń – 50% crossfitowców techniką „back squat" oraz 100% u trójboistów techniką „front squat".

Słowa kluczowe:

trójbój siłowy, crossfit, napięcie mięśniowe, sEMG

Introduction

In recent years, there has been an increased interest in undertaking resistance training, which is in line with current recommendations regarding physical activity [1]. Researchers also note that participants' motivation for this type of activity is turning from extrinsic to intrinsic [2, 3]. The most commonly reported motives for undertaking resistance training include: a feeling of enjoyment, challenge, sense of belonging, as well as positive effects on health and body weight reduction. As the popularity of strength sports, such as powerlifting and weightlifting has increased, so has the interest of researchers in these disciplines. Strength, identified as the ability to overcome or counteract external loads at the expense of muscular effort, is the main ability on which powerlifting is based [4, 5, 6]. During a competition, a powerlifting athlete has three attempts in each of the three disciplines: a barbell squat, barbell bench press and deadlift. The best results achieved in a single lift make up the total lifted weight. The barbell squat involves bending lower limbs in knee and hip joints and lowering the torso until the upper, proximal surface of the thighs is below the upper, distal surface of the thighs (in the International Powerlifting Federation regulations [7] referred to as "tops of the knees") and then returning to the upright position. The barbell press is performed in the supine position on a bench. The competitor lowers the barbell to the chest from the extended elbow position and then returns to the starting position at the referee's signal. While doing a deadlift, the competitor in the standing position lifts the barbell from the ground until the torso is fully straightened and the shoulders are retracted. The load is determined by the weight of the barbell. During competitions, athletes lift weights which are up to four times bigger than their body weight [8]. They compete against each other in various categories determined by gender, age and body weight. According to regulations of the International Powerlifting Federation [8], the minimum age of competitors is 14 years. Many authors in their studies have shown that physical characteristics, anthropometry, fat-free mass, skeletal muscle mass and bone mass are related to powerlifting performance and therefore to maximal strength [9, 10, 11]. Furthermore, other studies have assessed the relationship between anthropometry and bench press strength and in all three powerlifting disciplines [12]. Some authors also point out that factors such as the baseline strength level and changes in free-fat mass can negatively or positively influence strength development [13, 14]. Crossfit is another kind of workout aimed at developing strength. It improves elements of physical fitness, including motor characteristics (aerobic endurance, muscular strength and endurance, flexibility, speed, coordination, precision and control of movement, agility, balance and power) [15, 16, 17]. Training consists of various exercises aimed at improving different skills, i.e. weightlifting, rope climbing, carrying heavy weights on long distances. A training session usually lasts about an hour and consists of a warm-up, strength training and/or skill training, or fitness training for

about 30 minutes and finishes with lower-intensity workouts, including stretching [18]. In Crossfit classes, a training programme varies according to the individual athlete's fitness, training location, intensity, duration, organisational form and complexity and workouts are short but of high-intensity. Exercises are required to be done within certain time limits or the number of repetitions is maximum. They can be performed as individual, partner or group training [19, 20, 21]. Apart from comprehensive development of the body fitness, the training has a functional character and helps to adopt pro-healthy lifestyle. Training programmes are arranged according to the amount of load, intensity and interval between sets in order to suit people at different levels of advancement and training experience. A squat is one of the most commonly performed exercises in strength, endurance and fitness sports training, used to increase performance and build resistance to injuries [22, 23, 24]. This exercise involves activation of a large number of joints, which engages numerous muscle groups. In a squat, muscles are engaged to actively make the movement itself and stabilise the body during the movement, as well as maintain balance and coordination. Squats are essential for building muscle strength. However, squats can contribute to injuries if they are improperly performed [25, 26]. Performing a squat with a barbell is divided into several stages, and its technique is adjusted individually to the type of training and the athlete's predispositions. Both people practising Crossfit and powerlifting use two techniques, depending on their advancement stage of training. They are: "a front squat" (the bar is placed in front, on the shoulders) and "a back squat" (the bar is placed on the upper back). Performing a squat with a barbell held in front, due to a position of the centre of gravity and a forced position of the trunk, is highly difficult [31]. The muscles most involved in performing a front squat include: gluteus medius, gluteus maximus, rectus femoris, vastus lateralis, vastus medialis, vastus intermedius and erector spinae [27]. The "back squat" technique is less difficult so it is more preferable by less experienced athletes. However, it allows them to quickly achieve weight lifting progress. In performing a squat, the trunk leans forward. This movement engages the activation of biceps femoris muscles and posterior muscle bands [28].

Aim of this study was to evaluate resting muscle tone during a barbell squat in powerlifting and Crossfit athletes with the application of surface electromyography (sEMG) and to compare differences in the muscle tension depending on the technique of positioning the barbell, as well as to assess the subjective feeling of difficulty in performing a movement with a particular technique.

Material and Methods

Material

The study group consisted of 60 members of the Lodz Academic Sports Association and the FitFabric Fitness Club, aged 22–28 years (24 ± 2.8 years) divided into 2 gro-

ups, with 30 subjects in each. They included athletes training Crossfit and powerlifting. The inclusion criteria were: the male sex, age (22-28 years old), at least two-year training experience, ability to perform a full barbell squat with a load equal to the athlete's body weight, lack of contraindications to training, current medical examination results.

Methods

The muscle tension test was preceded by local hair removal and skin degreasing. Then, electrodes were placed on the skin to test the surface muscle tension, in accordance with SENIAM guidelines (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles). The study consisted of twelve repetitions of barbell squats, divided into two series. Series I consisted of six repetitions of a squat, performed with a barbell in the so-called Olympic style, i.e. "a back squat". Three repetitions were performed with a load of 20 kilograms. In the remaining three repetitions, the load was increased to equal the body weight of the athlete. In series II, the researchers used the same procedures but a front squat was performed. The test was conducted in sports shoes on a stable and flat surface.

Resting mean and maximal electrical tensions of the following muscles were measured: left and right tibialis anterior muscles, left and right vastus medialis, left and right rectus femoris, left and right gastrocnemius muscles, left and right biceps femoris, left and right gluteus medius, left and right gluteus maximus, left and right lumbar erector spinae.

After the first three repetitions with a load of 20 kilograms and after the next three repetitions with a load equal to the athlete's body weight in both series I and II, the subjective evaluation of the difficulty of performing the movement with a particular technique was performed on a two-grade scale, where 1 meant a movement performed without difficulty and 2 meant a movement performed with difficulty.

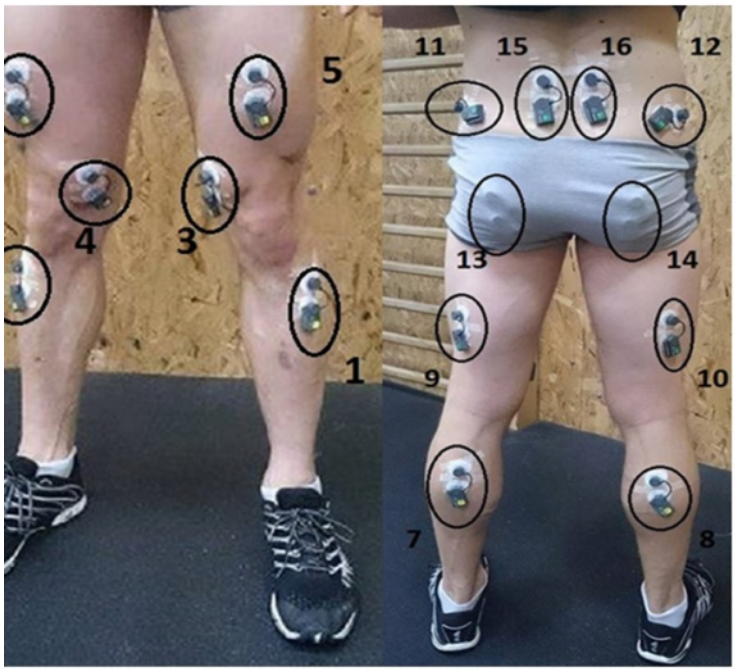
Besides, using a measuring tape (± 0.5), the authors made measurements of the lower limb circumferences of the gluteus firstus, gluteus secondus, femur firstus, femur secondus, shin firstus, shin secondus muscles.

Measurements of the electrical activity of the muscles were performed using a FREEEMG300 EMG electromyograph (BTS Bioengineering), borrowed from the Academic Laboratory of Movement and Human Physical Performance "DynamoLab" of the Medical University of Lodz.

Bio Lead – Lok B R – LFO – 320 electrodes, 32 mm/36 mm in size, based on a sponge with solid gel and Ag/AgCl sensor, were used for the study.

The sEMG examination was performed during a barbell squat in various phases, i.e. immediately before the initiation of the movement, during the full squat phase, and after its completion but before putting the barbell back on the rack.

Data obtained in the study were processed using the SMARTanalyzer software – version 1.10.0225. The following filters used were: 20 Hz high-pass Butterworth filter and 450 Hz low-pass Butterworth filter. The signal was rectified and the root of the square of the mean value was calculated using a 300 ms time window.



Przypisanie elektrod EMG wybranym mięśniom
Assign EMG electrodes to selected muscles

Nr elektrody Electrode number	Mięśnie – strona lewa Muscles - left side	Nr elektrody Electrode number	Mięśnie – strona prawa Muscles - right side
1.	mięsień piszczelowy przedni tibialis anterior muscle	2.	mięsień piszczelowy przedni tibialis anterior muscle
3.	mięsień obszerny przyśrodkowy vastus medialis muscle	4.	mięsień obszerny przyśrodkowy vastus medialis muscle
5.	mięsień prosty uda rectus femoris muscle	6.	mięsień prosty uda rectus femoris muscle
7.	mięsień brzuchaty łydki gastrocnemius muscle	8.	mięsień brzuchaty łydki gastrocnemius muscle
9.	mięsień dwugłowy uda biceps femoris muscle	10.	mięsień dwugłowy uda biceps femoris muscle
11.	mięsień pośladkowy średni gluteus medius muscle	12.	mięsień pośladkowy średni gluteus medius muscle
13.	mięsień pośladkowy wielki gluteus maximus muscle	14.	mięsień pośladkowy wielki gluteus maximus muscle
15.	mięsień prostownik grzbietu w części lędźwiowej kręgosłupa lumbar erector spinae muscle	16.	mięsień prostownik grzbietu w części lędźwiowej kręgosłupa lumbar erector spinae muscle

Fig.1. Location of EMG electrodes according to the assigned numbering on the appropriate muscle actons (source: Archives of the Sports Center of the Medical University of Łódź)

Statistical analysis methods

The authors calculated values of the mean, standard deviation and median in the analysed variables by the application of the Shapiro-Wilk test. It enabled to determine whether the distribution of the analysed variables is normal. The hypotheses were verified using parametric and non-parametric tests. The t-test was applied for variables of normal distribution and homogeneous variances. For variables of normal distribution and non-heterogeneous variances, the separate-variance t-test was applied. The Mann-Whitney U test was used for a variable inconsistent with the normal distribution. The level $\alpha = 0.05$ was adopted as significant. The Statistica v. 10 package, licence no: AXAP301E504323AR-B as well as Microsoft Excel from Microsoft Office 2010 were used for statistical purposes.

All study subjects signed an informed consent to participate in the study. The Bioethics Committee of the Medical University of Lodz gave its consent to conduct the study (no: RNN/127/15/KB, dated 17 February, 2015).

Results

The mean values of body weight and height of the studied athletes training Crossfit and powerlifting are presented in Figure 2. The studied groups were homogeneous in terms of body weight and height. The Mann-Whitney U-test showed no differences in body weight (p-value = 0.2604) and the t-test showed no differences in height between the groups (p-value = 0.4387). There were no statistically significant differences in lower limb circumferences between powerlifting and Crossfit athletes.

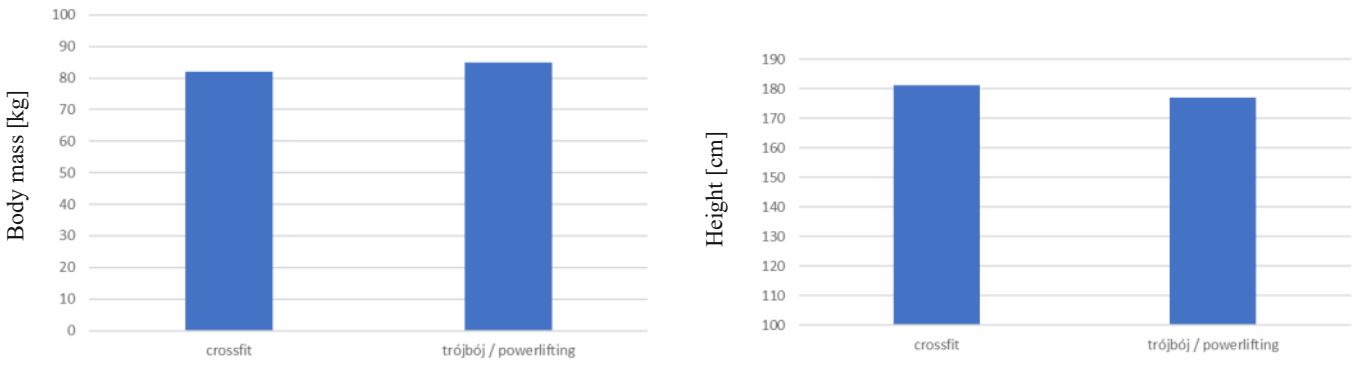


Fig. 2a and 2b. Average height and average body weight of athletes

Mean values of muscle tension

The mean value of resting muscle tension depending on the trained discipline

Obtained mean values of resting muscle tension of the athletes are presented in Table 1. A comparative analysis showed significantly higher mean resting tension of the biceps femoris musclein the left lower limb in athletes practising Crossfit (the Mann-Whitney U-test: $Z = -1.9888$, p-value = 0.0467). For other muscles, no statistically significant differences were found in the compared groups of athletes.

Table 1. Descriptive statistics for the average resting muscle tone of athletes practicing Crossfit or powerlifting and the statistical significance of the differences

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
left tibialis anterior	6.064	2.475	7.116	3.268	2.423	2.862	p > 0,05
right tibialis anterior	7.967	2.488	9.912	11.347	2.408	39.229	p > 0.05
left vastus medialis	3.265	2.683	1.703	2.778	2.553	0.686	p > 0.05
right vastus medialis	2.739	2.332	1.352	2.588	2.264	0.615	p > 0.05
left rectus femoris	2.641	2.366	0.941	2.513	2.545	0.241	p > 0.05
right rectus femoris	2.486	2.341	0.547	2.389	2.380	0.311	p > 0.05
left gastrocnemius	2.455	2.272	0.485	2.527	2.300	0.714	p > 0.05
right gastrocnemius	2.831	2.413	1.780	3.220	2.493	2.770	p > 0.05
left biceps femoris	9.173	2.793	12.584	7.407	2.447	13.757	p < 0.05
right biceps femoris	5.194	2.643	6.686	6.296	2.644	9.241	p > 0.05

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
left gluteus medius	3.785	2.662	3.268	4.505	2.577	6.488	p > 0.05
right gluteus medius	4.346	2.950	3.236	3.459	2.969	2.145	p > 0.05
left gluteus maximus	8.956	2.408	30.009	3.632	2.412	4.779	p > 0.05
right gluteus maximus	2.959	2.467	1.272	3.231	2.501	2.971	p > 0.05
left lumbar erector spinae	6.832	2.834	11.980	6.925	2.721	13.753	p > 0.05
right lumbar erector spinae	6.967	3.683	9.008	7.401	3.412	12.806	p > 0.05

The mean value of muscle tension during a back squat with a load of 20 kilograms

A statistical analysis showed significantly higher mean muscle tension in the group of Crossfit athletes during a performance of a back squat with a load of 20 kilograms in the following muscles:

- the right tibialis anterior muscle (t-test results: $t = -2.0894$, p-value = 0.0420);
- the right gluteus medius muscle (the U Mann-Whitney test results: $Z = -2.2313$, p-value = 0.0257);
- the left erector spinae muscle (the U Mann-Whitney test results: $Z = -2.1731$, p-value = 0.0298);
- the right erector spinae muscle (the U Mann-Whitney test results: $Z = -1.9791$, p-value = 0.0478).

For other muscles, no statistically significant differences were found for the compared groups of athletes. Results are presented in Table 2.

Table 2. Descriptive statistics of the mean value of muscle tension during the performance of the squat with the bar using the "back squat" technique of athletes practicing powerlifting or powerlifting

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
piszczelowy przedni lewy left tibialis anterior	132.713	111.582	47.119	122.107	123.451	46.911	p > 0.05
piszczelowy przedni prawy right tibialis anterior	133.540	127.307	39.949	111.382	114.494	34.866	p < 0.05
obszerny przyśrodkowy lewy left vastus medialis	89.487	86.445	24.427	81.597	74.827	22.281	p > 0.05
obszerny przyśrodkowy prawy right vastus medialis	83.883	80.842	21.453	85.296	83.436	22.362	p > 0.05
prosty uda lewy left rectus femoris	63.294	62.790	20.644	62.194	59.283	25.171	p > 0.05

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
right rectus femoris	65.842	66.866	25.118	61.263	60.084	21.774	p > 0.05
left gastrocnemius	32.394	30.800	16.629	29.325	28.263	8.006	p > 0.05
right gastrocnemius	29.604	28.445	8.071	31.548	28.881	9.169	p > 0.05
left biceps femoris	46.401	46.451	14.367	41.758	40.316	17.403	p > 0.05
right biceps femoris	37.000	36.433	11.977	38.336	38.682	15.300	p > 0.05
left gluteus medius	31.035	27.049	11.132	28.037	23.370	15.330	p > 0.05
right gluteus medius	38.072	34.550	12.661	30.018	27.941	15.800	p < 0.05
left gluteus maximus	20.179	18.764	10.377	19.800	16.438	11.147	p > 0.05
right gluteus maximus	20.712	17.308	14.520	18.366	14.408	13.112	p > 0.05
left lumbar erector spinae	75.840	72.251	26.448	89.280	54.486	120.607	p < 0.05
right lumbar erector spinae	80.097	78.054	27.539	84.222	59.431	110.620	p < 0.05

The mean value of muscle tension during a front squat with a load of 20 kilograms in the following muscles

A statistical analysis showed significantly higher mean muscle tension in the group of Crossfit athletes during a performance of a front squat with a load of 20 kilograms in the following muscles:

- the right gluteus medius muscle (the U Mann-Whitney test results: Z = −2.5224, p-value = 0.0117);
- the right erector spinae muscle (the U Mann-Whitney test results: Z = −2.6000, p-value = 0.0093).

For other muscles, no statistically significant differences were found for the compared groups of athletes. Results are presented in Table 3.

Table 3. Descriptive statistics of the mean value of muscle tone during the performance of the squat with the bar using the "front squat" technique in athletes practicing Crossfit or powerlifting

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
left tibialis anterior	129.892	127.658	44.684	119.120	118.596	42.995	p > 0.05
right tibialis anterior	129.434	131.907	38.986	111.789	106.843	35.232	p > 0.05

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
left vastus medialis	89.442	87.362	22.603	83.428	75.678	27.383	p > 0.05
right vastus medialis	82.857	81.016	20.544	87.817	86.863	27.042	p > 0.05
left rectus femoris	65.881	62.482	21.001	62.800	61.333	23.225	p > 0.05
right rectus femoris	66.488	70.055	22.130	65.712	66.090	18.828	p > 0.05
left gastrocnemius	31.596	29.615	16.099	28.482	28.453	6.886	p > 0.05
right gastrocnemius	30.335	28.201	8.951	28.826	27.147	7.251	p > 0.05
left biceps femoris	46.890	46.221	12.765	42.623	40.298	17.354	p > 0.05
right biceps femoris	40.459	37.052	14.105	36.906	37.535	11.471	p > 0.05
left gluteus medius	33.446	30.572	10.221	29.843	24.450	16.587	p > 0.05
right gluteus medius	40.299	36.526	11.711	31.288	25.378	15.732	p < 0.05
left gluteus maximus	20.682	17.331	10.024	21.728	19.671	12.269	p > 0.05
right gluteus maximus	21.925	16.503	14.082	20.161	15.807	13.697	p > 0.05
left lumbar erector spinae	97.464	98.024	33.103	98.749	68.620	116.688	p > 0.05
right lumbar erector spinae	100.697	89.273	37.730	125.973	77.184	166.530	p < 0.05

The mean value of muscle tension during front and back squats with a load equal to the body weight of Crossfit and powerlifting athletes.

A statistical analysis did not confirm statistically significant differences in the mean muscle tension during a back squat with a load equal to the body weight of Crossfit and powerlifting athletes. With regards to a front squat, performed with such a load, no statistically significant differences were observed for the two analysed groups, either. Results are presented in tables: 4 and 5.

Table 4. Descriptive statistics of average muscle tone values during the squat with a load equal to the athlete's body weight using the "back squat" technique in athletes practicing Crossfit or powerlifting

Muscle	Rest voltage [µV]						p-value
	Crossfit			Powerlifting			
	Average [µV]	Median [µV]	SD [µV]	Average [µV]	Median [µV]	SD [µV]	
left tibialis anterior	386.859	390.159	111.850	404.449	409.166	121.649	p > 0.05
right tibialis anterior	412.509	393.840	84.118	385.446	373.802	96.976	p > 0.05
left vastus medialis	508.290	527.036	97.736	476.748	463.870	116.466	p > 0.05
right vastus medialis	476.636	481.348	102.521	503.075	463.777	118.474	p > 0.05
left rectus femoris	435.729	433.156	131.695	448.757	415.573	161.628	p > 0.05
right rectus femoris	461.288	474.526	176.898	468.195	469.056	140.125	p > 0.05
left gastrocnemius	148.248	142.811	64.370	140.894	138.256	41.475	p > 0.05
right gastrocnemius	165.851	172.213	54.463	168.848	157.439	63.428	p > 0.05
left biceps femoris	225.528	212.915	76.098	234.629	196.570	91.328	p > 0.05
right biceps femoris	244.092	185.900	220.649	187.268	151.566	84.445	p > 0.05
left gluteus medius	133.883	129.765	46.194	128.618	106.966	73.009	p > 0.05
right gluteus medius	156.631	146.030	59.719	135.819	127.191	65.197	p > 0.05
left gluteus maximus	201.162	189.968	84.081	195.173	162.226	108.199	p > 0.05
right gluteus maximus	205.428	181.550	78.396	182.216	165.339	100.202	p > 0.05
left lumbar erector spinae	407.524	386.903	124.240	406.711	376.797	150.310	p > 0.05
right lumbar erector spinae	407.015	398.544	125.401	418.065	400.824	207.482	p > 0.05

Table 5. Descriptive statistics of the average muscle tension during the squat with a load equal to the body weight of the competitor using the "front squat" technique in competitors practicing Crossfit or powerlifting

Muscle	Rest voltage [µV]						p-value
	Crossfit			Powerlifting			
	Average [µV]	Median [µV]	SD [µV]	Average [µV]	Median [µV]	SD [µV]	
left tibialis anterior	126.293	119.872	41.011	126.449	124.679	42.174	p > 0.05

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
right tibialis anterior	446.398	418.163	90.285	425.589	425.357	104.535	p > 0.05
left vastus medialis	556.242	533.671	138.317	502.703	487.834	124.092	p > 0.05
right vastus medialis	515.855	492.047	144.612	577.970	546.181	128.816	p > 0.05
left rectus femoris	489.832	516.135	95.089	511.398	466.583	159.383	p > 0.05
right rectus femoris	513.246	470.042	144.497	537.322	530.101	125.002	p > 0.05
left gastrocnemius	161.731	148.619	64.598	142.193	128.879	39.940	p > 0.05
right gastrocnemius	183.210	156.289	107.688	180.473	156.290	78.483	p > 0.05
left biceps femoris	239.133	235.239	83.985	258.100	239.900	94.913	p > 0.05
right biceps femoris	276.025	236.191	208.429	229.460	209.055	92.052	p > 0.05
left gluteus medius	162.816	160.952	52.020	146.250	135.546	57.100	p > 0.05
right gluteus medius	186.477	177.221	52.236	161.189	143.422	54.687	p > 0.05
left gluteus maximus	229.087	225.366	86.370	233.782	219.108	97.580	p > 0.05
right gluteus maximus	244.270	246.335	82.047	228.241	225.346	95.462	p > 0.05
left lumbar erector spinae	432.487	400.846	116.527	384.549	386.831	105.644	p > 0.05
right lumbar erector spinae	421.797	406.367	122.819	393.535	358.405	118.598	p > 0.05

A statistical analysis confirmed statistically significant differences in the maximum value of muscle tension during a back squat with a load of 20 kilograms in the following muscles:

- the left gluteus medius muscle (the U Mann-Whitney test results: $Z = -2.4642$, p-value = 0.0137);
- the right gluteus medius muscle (the U Mann-Whitney test results: $Z = -2.0761$, p-value = 0.0379).

In Crossfit athletes, the maximal tensions of the above muscles were higher than in powerlifting athletes. Results are presented in Table 6.

Table 6. Descriptive statistics of the maximum value of muscle tension during the performance of the squat with the bar using the "back squat" technique in athletes practicing Crossfit or powerlifting

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
left tibialis anterior	460.288	448.041	141.757	422.655	407.405	119.387	p > 0.05
right tibialis anterior	454.560	449.120	132.494	405.912	380.171	118.839	p > 0.05
left vastus medialis	352.096	353.073	88.003	319.335	295.901	89.167	p > 0.05
right vastus medialis	322.202	288.625	96.014	352.145	338.709	96.786	p > 0.05
left rectus femoris	256.060	245.487	103.175	304.606	261.664	157.438	p > 0.05
right rectus femoris	273.703	253.545	131.664	270.948	257.163	114.265	p > 0.05
left gastrocnemius	102.985	96.930	51.788	102.080	98.270	38.756	p > 0.05
right gastrocnemius	115.609	106.092	62.735	105.392	93.962	42.657	p > 0.05
left biceps femoris	136.443	136.331	48.334	153.054	119.644	91.175	p > 0.05
right biceps femoris	115.859	109.857	47.527	125.264	108.949	67.053	p > 0.05
left gluteus medius	90.834	89.295	33.086	74.351	65.030	50.711	p < 0.05
right gluteus medius	102.514	91.986	43.279	84.813	68.121	64.886	p < 0.05
left gluteus maximus	78.005	67.737	43.349	79.417	67.882	53.431	p > 0.05
right gluteus maximus	81.332	65.855	57.957	75.969	54.002	62.896	p > 0.05
left lumbar erector spinae	298.890	265.786	112.578	328.682	228.091	273.554	p > 0.05
right lumbar erector spinae	289.662	282.636	90.302	285.725	237.561	195.366	p > 0.05

With regards to performing a front squat, there were no statistically significant differences in the values of the maximum tension in athletes practicing Crossfit and powerlifting. Results are presented in Table 7.

Table 7. Descriptive statistics of the maximum muscle tone during the front squat performed by competitors practicing Crossfit or powerlifting

Muscle	Rest voltage [μV]						
	Crossfit			Powerlifting			p-value
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
left tibialis anterior	449.953	467.795	137.305	423.385	428.978	149.474	p > 0.05
right tibialis anterior	448.718	457.260	111.754	404.538	366.637	136.145	p > 0.05
left vastus medialis	351.505	339.082	86.934	332.066	346.034	78.439	p > 0.05
right vastus medialis	328.434	331.609	76.272	371.350	370.983	90.909	p > 0.05
left rectus femoris	237.400	233.557	97.650	280.345	254.609	142.716	p > 0.05
right rectus femoris	258.718	229.433	123.094	285.507	295.993	114.968	p > 0.05
left gastrocnemius	96.953	85.417	53.903	99.967	84.873	45.497	p > 0.05
right gastrocnemius	114.201	95.239	53.275	109.330	91.273	53.904	p > 0.05
left biceps femoris	141.552	136.720	46.367	142.638	116.168	59.664	p > 0.05
right biceps femoris	146.908	121.542	63.533	125.876	112.377	57.773	p > 0.05
left gluteus medius	85.714	82.385	28.703	82.175	61.782	59.414	p > 0.05
right gluteus medius	106.125	96.004	42.946	88.313	73.631	55.095	p > 0.05
left gluteus maximus	97.018	91.120	52.796	85.450	86.084	49.444	p > 0.05
right gluteus maximus	91.452	84.822	52.742	83.988	63.568	57.591	p > 0.05
left lumbar erector spinae	338.859	317.629	120.091	312.644	226.976	247.921	p > 0.05
right lumbar erector spinae	350.130	323.970	110.799	351.112	244.384	273.286	p > 0.05

The mean values of maximal muscle tension during back and front squats with a load equal to the athlete's body weight in Crossfit or powerlifting subjects.

A statistical analysis did not confirm statistically significant differences in the mean values of maximal muscle tension during a back squat with a load equal to the body weight of Crossfit and powerlifting athletes. With regards to a front squat, performed with a load equal to the body weight of Crossfit and powerlifting athletes, no statistically significant differences were observed, either. Results are presented in Tables: 8 and 9.

Table 8. Descriptive statistics for the average value of the maximum muscle tone during a squat with a load equal to the body weight of a competitor using the "back squat" technique in competitors practicing or powerlifting

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
left tibialis anterior	386.859	390.159	111.85	404.449	409.166	121.65	p > 0.05
right tibialis anterior	412.509	393.840	84.118	385.446	373.802	96.976	p > 0.05
left vastus medialis	508.290	527.036	97.736	476.748	463.870	116.466	p > 0.05
right vastus medialis	476.636	481.348	102.52	503.075	463.777	118.474	p > 0.05
left rectus femoris	435.729	433.156	131.69	448.757	415.573	161.628	p > 0.05
right rectus femoris	461.288	474.526	176.89	468.195	469.056	140.125	p > 0.05
left gastrocnemius	148.248	142.811	64.370	140.894	138.256	41.475	p > 0.05
right gastrocnemius	165.851	172.213	54.463	168.848	157.439	63.428	p > 0.05
left biceps femoris	225.528	212.915	76.098	234.629	196.570	91.328	p > 0.05
right biceps femoris	244.092	185.900	220.64	187.268	151.566	84.445	p > 0.05
left gluteus medius	133.883	129.765	46.194	128.618	106.966	73.009	p > 0.05
right gluteus medius	156.631	146.030	59.719	135.819	127.191	65.197	p > 0.05
left gluteus maximus	201.162	189.968	84.081	195.173	162.226	108.199	p > 0.05
right gluteus maximus	205.428	181.550	78.396	182.216	165.339	100.202	p > 0.05
left lumbar erector spinae	407.524	386.903	124.24	406.711	376.797	150.310	p > 0.05
right lumbar erector spinae	407.015	398.544	125.40	418.065	400.824	207.482	p > 0.05

Table 9. Descriptive statistics for the average value of the maximum muscle tone during a squat with a load equal to the body weight of a competitor using the "front squat" technique in competitors practicing Crossfit or powerlifting

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
piszczelowy przedni lewy	444.274	450.155	60.194	450.829	463.069	125.751	p > 0.05

Muscle	Rest voltage [μV]						p-value
	Crossfit			Powerlifting			
	Average [μV]	Median [μV]	SD [μV]	Average [μV]	Median [μV]	SD [μV]	
right tibialis anterior	131.532	117.167	38.886	120.071	118.525	28.702	p > 0.05
left vastus medialis	125.182	116.513	32.690	117.337	108.177	31.036	p > 0.05
right vastus medialis	116.942	108.273	33.203	120.695	120.625	27.318	p > 0.05
left rectus femoris	92.051	87.660	29.031	87.697	90.976	21.567	p > 0.05
right rectus femoris	93.744	87.462	33.776	90.641	87.466	24.081	p > 0.05
left gastrocnemius	47.149	42.390	21.903	46.312	44.124	12.463	p > 0.05
right gastrocnemius	48.981	48.028	14.528	52.293	48.364	17.809	p > 0.05
left biceps femoris	79.930	76.976	18.996	78.759	70.157	30.117	p > 0.05
right biceps femoris	88.660	67.939	106.671	68.784	62.433	25.319	p > 0.05
left gluteus medius	48.714	47.469	14.615	48.055	45.066	24.921	p > 0.05
right gluteus medius	60.043	57.939	16.480	50.901	51.902	22.846	p > 0.05
left gluteus maximus	41.777	38.600	14.662	43.114	41.321	20.986	p > 0.05
right gluteus maximus	42.594	38.604	18.488	40.740	29.875	23.876	p > 0.05
left lumbar erector spinae	120.767	117.862	27.517	112.728	108.464	41.524	p > 0.05
right lumbar erector spinae	125.013	119.078	35.577	112.435	107.511	37.299	p > 0.05

Subjective evaluation of the level of difficulty of exercises

An analysis of results of a questionnaire on the level of difficulty of exercises showed that 50% of Crossfit athletes reported difficulty in performing a back squat with a 20-kilogram barbell and with a load equal to the athlete's body weight. None of the subjects practising Crossfit reported difficulty in performing a front squat. In contrast, 100% of the powerlifting athletes reported difficulty performing a front squat, both with a 20-kilogram load as well as with a equal to the athlete's body weight. None of the respondents practising powertlifting reported difficulty in performing a back squat.

Discussion

The leading techniques in barbell squat training are different for particular groups. In powerlifting, a back squat is the

preferred starting and training technique, whereas in Crossfit, a front squat is such a technique. These differences did not however significantly affect results of muscle tension measurements. Thus, it can be concluded that properly selected accessory exercises allow to obtain such measurements. Although these two techniques are not simultaneously used in training, they engage all muscles in performing physical exercise.. When designing exercises for each group, it is important to optimally select an exercise programme to minimise the risk of injury. Powerlifting athletes sustain on average 1.0-4.4 injuries per 1,000 training hours. Strömbäck et al. [29] included more than 100 powerlifting athletes in his study. He observed that up to 87% of the participants suffered an injury in the past year and most injuries occurred during a barbell squat. In most cases, the lumbosacral region, shoulder joints and hip joints were exposed to injuries. Causes of injuries included excessive training loads, an incorrect technique and the fact that training sessions were not held systematically. The injury rate ranges from 0.74 to 3.3 per 1,000 training hours. Injuries have been observed to most commonly affect the shoulder joints, the lumbosacral spine [30, 31, 32] and hip joints and are usually caused by excessive training. Surface electromyography (sEMG) is a quantitative method of assessing the electrical activity of muscles, useful in planning and monitoring training. While performing squats, the following muscles demonstrate their highest bioelectrical activity: rectus femoris, vastus lateralis, vastus medialis, gluteus maximus, biceps femoris, and semitendinosus [33, 34, 35]. Activation of particular muscles is important while planning training sessions and is a basis for a proper selection of exercises to effectively strengthen selected muscles and achieve the desired effect. It is also a tool for determining whether the squat was performed technically properly and allows to identify possible irregularities resulting from excessive activation of the wrong muscle groups. If the pattern for performing a given movement is disturbed, compensatory mechanisms are developed to compensate for the deficit, which may hinder the achievement of appropriate sports results and increase the risk of injury [26, 36]. On the basis of the conducted research and analysis of results, the authors observed a significant difference in the mean and maximum values of muscle tension between the group practicing Crossfit and powerlifting. In each case, the electrical activity of muscles was higher in Crossfit athletes. The above relationship can be explained by the fact that, compared with powerlifting, Crossfit is a more comprehensive discipline which improves not only strength and muscular endurance, but also flexibility, speed, coordination, precision and control of movement, agility, balance and power. Differences in the training plan and in shaping of various motor abilities and characteristics may also be the reason for different subjective assessment of difficulty in performing back and front squats [37, 38]. All powerlifting athletes reported difficulty in performing

a barbell front squat, which, due to its specificity, is more difficult to do. Only 50% of the Crossfit athletes reported difficulty in performing a barbell back squat. Such results may imply that exercises selected for training sessions in both study groups are aimed to strengthen different muscle groups, which are most involved in the performance of the squat with a given technique. In contrast, the fact that the Crossfit group twice less frequently report difficulty performing a squat may be caused by their more comprehensive training although differences in both the groups were observed only for muscles which were most activated during a particular squat. Obtained results differ from those obtained by other authors [34, 39] who revealed which muscle groups are most involved in the performance of a back squat or a front squat. Results obtained by the authors of this study revealed that during squats – both front and back, performed with different loads, the following muscles were most active: tibialis anterior, erector spinae, vastus medialis and rectus femoris. The above muscles were most active in both groups of athletes. In order to designate training and assess the risk of injuries, the authors found it important to analyse results of individual measurements considering differences in the muscle activity on the right and left side and abnormal reduced activity of some muscles in favour of others. Obtained results can be used to optimise the technique of performing squats, depending on the type of sports discipline (powerlifting/crossfit) in order to increase the effectiveness of training and to avoid injuries, resulting mainly from inappropriate loading of the musculoskeletal system. The observed differences in muscle activity can be useful in designing training exercises and improving motor skills for people practising Crossfit and powerlifting. When designing exercises, attention should be paid to the difficulty of performing squats, both front and back ones. Due to the young age of the athletes, their short training experience, and a small size of the studied groups, it is necessary to continue research in this area in order to determine whether the bioelectrical activity of muscles will depend on the training experience, trained discipline, and load, and whether individual muscle groups, affected by different loads, will be more or less active in favour of others.

Conclusions

1. On the basis of the study and analysis of the results, the authors revealed that Crossfit athletes demonstrate statistically higher muscle activity while performing both front and back squats with a load of 20 kilograms and a load equal to their body weight in comparison to athletes practising powerlifting.
2. An analysis of subjective assessment of difficulty performing exercises indicated that the perception of difficulty depends on the technique of doing the exercise, which may result from considerable differences in training programmes and a selection of lower limb exercises of both groups of athletes.

Adres do korespondencji / Corresponding author

Kamila Pasternak

e-mail: kamila.pasternak@umed.lodz.pl

Piśmiennictwo/ References

1. Dominski F.H., Serafim T.T., Siqueira T.C. et al., Psychological variables of CrossFit participants: a systematic review. Sport Sci. Health. 2021; 17: 21–41.
2. Heinrich K.M., Patel P.M., O'Neal J.L. Et al., High-intensity compared to moderate-intensity training for exercise initiation, enjoyment, adherence, and intentions: an intervention study. BMC Public Health. 2014; Aug 3;14:789. doi: 10.1186/1471-2458-14-789. PMID: 25086646; PMCID: PMC4129110.;
3. Fisher J., Steele J., Smith D., High- and Low-Load Resistance Training: Interpretation and Practical Application of Current Research Findings. Sports Med. 2017; Mar 47(3): 393-400. doi: 10.1007/s40279-016-0602-1. PMID: 27480764.
4. Fisher J.P., Steele J. Heavier and lighter load resistance training to momentary failure produce similar increases in strength with differing degrees of discomfort. Muscle Nerve. 2017; Oct 56(4):797-803. doi: 10.1002/mus.25537. Epub 2017 Apr 17. PMID: 28006852.
5. Travis S.K., Mizuguchi S. et al., Preparing for a National Weightlifting Championship: A Case Series. J. Strength Cond. Res. 2020; Jul 34 (7): 1842-1850. doi: 10.1519/JSC.0000000000003312. PMID: 31373973.
6. International Powerlifting Federation. Home page. Availableat: http://www.powerlifting-ipf.com/. Accessed May 07, 2021.
7. Fry, A., C., Smith, J., C., Schilling, B., K. Effect of knee position on hip and knee torques during the barbell squat. Journal of Strength and Conditioning Research, 2003;17 :629–633.
8. Keogh J.W., Hume P.A., Pearson S.N. et al., Canabsolute and proportional anthropometric characteristics distinguish stronger and weaker powerlifters? J. Strength Cond. Res. 2009; 23 (8): 2256–2265.
9. Ye X., Loenneke J.P., Fahs C.A. et al., Relationship between lifting performance and skeletal muscle mass in elite power lifters. J. Sports Med. Phys. Fitness. 2013; Aug 53 (4): 409-14. PMID: 23828289.;
10. Reynolds J.M., Gordon T.J., Robergs R.A., Prediction of one repetition maximum strength from multiplerepetition maximum testing and anthropometry. J. Strength Cond. Res. 2006; 20 (3): 584–592.
11. Schumacher R.M., Arabas J.L., Mayhew J.L. et al., Inter-investigator reliability of anthropometric prediction of 1rm benchpress in college football players. Int. J. Exerc. Sci. 2016; 9 (4): 427–436.
12. Appleby B., Newton R.U., Cormie P., Changes in strengthover a 2-year period in professional rugby unionplayers. J. Strength Cond. Res. 2012; 26: 2538–2546
13. Baker D.G. 10-year changes in upper body strength and power in elite professional rugby league players-the effect of training age, stage, and content. J. Strength Cond. Res. 2013; 27: 285–292.
14. Lichtenstein M.B., Jensen T.T., Exercise addiction in: prevalence and psychometric properties of the Exercise Addiction Inventory. Addict. Behav. Rep. 2016;3:33–37.
15. Moran S., Booker H., Staines J.et al., Rates and risk factors of injury in : a prospective cohort study. J. Sports Med. Phys. Fitness. 2017; 57 (9): 1147–1153.
16. Butcher S.J., Neyedly T.J., Horvey K.J.et al., Do physiological measures predictselected ((R)) benchmark performance? Open Access J. Sports Med. 2015;6:241–247. doi: 10.2147/OAJSM.S88265
17. Claudino J.G., Gabbett T.J., Bourgeois F.et al. .Overview: Systematic Review and Meta-analysis. Sports Med. Open. 2018; 4 (1): 11. doi: 10.1186/s40798-018-0124-5.
18. Mangine G.T., Cebulla B., Feito Y. Normative Values for Self-Reported Benchmark Workout Scores in (R) Practitioners. Sports Med. Open. 2018; 4 (1): 39. doi: 10.1186/s40798-018-0156-x.
19. Wagener S., Hoppe M.W., Hotfiel T. et al., Sportorthopa¨die-Sporttraumatologie. 2020; Sep 36(3): 241–249. Published online 2020 Sep 4. doi: 10.1016/j.orthtr.2020.07.001.
20. Miletello W.M., Beam J.R., Cooper Z.C., A biomechanical analysis of the squat between competitive collegiate, competitive high school, and novice powerlifters. J Strength Cond. Res. 2009; 23: 1611–1617.
21. Myer G.D., Brent J..L, Ford K. R. et al., Real-time assessment and neuromuscular training feedback techniques to prevent ACL injury in female athletes. Strength Cond. J. 2011;33:21–35.
22. Myer G.D., Kushner A.M., Brent J.L. et al., The Back Squat: A Proposed Assessment of Functional Deficits and Technical Factors That Limit Performance. Strength and Conditioning Journal 2014; 36 (6): 4-27.
23. Brocki K.C., Bohlin G. Executive functions in children aged 6 to 13: a dimensional and develop mental study. Dev. Neuropsychol. 2004;26:571–593.
24. Hirth CJ. Clinical Evaluation &Testing Clinical Movement Analysis to Identify Muscle Imbalances and Guide Exercise. Athletic Ther Today. 2007; 12:10.
25. Chandler T.J., Stone M.H., The squat exercise in athletic conditioning: A position statement and review of the literature. National Strength and Condition Association, 1991; 13:51–58.
26. Schoenfeld J.B., Squatting kinematics and their application to exercise performance. Journal of Strength and Conditioning Research. 2010; 24,12 :3497-3503.
27. Yule S. Exercise of the month: The backsquat. Professional Strength Conditioning. 2005; 1:11–15.
28. Aasa U., Svartholm I., Andersson F. et. al., Injuries among weightlifters and powerlifters: a systematic review. Br. J. Sports Med. 2017; 51:211–219.
29. Elkin J.L., Kammerman J.S., Kunselman A.R. et al., Likelihood of Injury and Medical Care Between and Traditional Weightlifting Participants. Orthop J. Sports Med. 2019;7 (5) doi: 10.1177/2325967119843348. 2325967119843348.
30. Feito Y., Burrows E.K., Tabb L.P. A 4-Year Analysis of the Incidence of Injuries Among Trained Participants. Orthop. J. Sports Med. 2018; 6 (10) doi: 10.1177/2325967118803100. 2325967118803100.
31. Muyor J.M., Martín-Fuentes I. et al., Electromyographic activity in the gluteus medius, gluteus maximus, biceps femoris, vastus lateralis, vastus medialis and rectus femoris during the Monopodal Squat, Forward Lunge and Lateral Step-Up exercises PLoS One. 2020; 15(4): e0230841.
32. Knoll M.G., Mackenzie D., Wraspir C.et al., Comparisons of Single Leg Squat Variations on Lower Limb Muscle Activation and Center of Pressure Alteration Int. J. Exerc. Sci. 2019; 12(1): 950–959. Published online 2019 Aug 1. PMCID: PMC6719809PMID: 31523343
33. Marchetti P.H., Jarbas da Silva J., Jon Schoenfeld B. et al., Muscle Activation Differs between Three Different Knee Joint-Angle Positions during a Maximal Isometric Back Squat Exercise. J. Sports. Med. (Hindawi Publ. Corp.). 2016;2016:3846123. doi: 10.1155/2016/3846123. Epub 2016 Jul 18. PMID: 27504484; PMCID: PMC4967668.
34. Hasan U.Y., Erdag D., Kinematic and Electromyographic Activity Changes during Back Squat with Submaximal and Maximal Loading. Appl. Bionics Biomech. 2017; 2017: 9084725. Published online 2017 May 4. doi: 10.1155/2017/9084725 PMCID: PMC5435978 PMID: 28546738
35. Lloyd R. S., Faigenbaum A. D., Stone M. H., et al. Positionstatement on youthresistancetraining: the 2014 internationalconsensus. British Journal of Sports Medicine. 2014;48(7):498–505. doi: 10.1136/bjsports-2013-092952
36. Lichtenstein M.B., Jensen T.T., Exercise addiction in : prevalence and psychometric properties of the Exercise Addiction Inventory. Addict. Behav. Rep. 2016;3:33–37.
37. Tibana RA, de Farias DL, Nascimento D, .et al., Relação da forçamuscular com o desempenho no levantamentoolímpico em praticantes.Revista Andaluza de Medicina del Deporte. 2016;112:84–88.