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Physical Fitness Profile in Female Horseback Riders

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ABSTRACT

BACKGROUND: The purpose of the present study was to examine the levels of endurance and neuromuscular performance variables in female horseback riders.

METHODS: 52 female Finnish riders were involved (age 29.4±8.9 yrs, height 1.68±0.06 m, weight 67.5±10.0 kg), 19 show-jumping riders (SJ) and 33 eventing riders (E), riding-time minimum of 4 times/week, jumping level of minimum 1.06±0.11m. The measurements were maximal bilateral isometric leg press force (MVC_{LP}), maximal unilateral isometric knee extension (MVC_{KE}) and flexion forces (MVC_{KF}), countermovement jump (CMJ), maximal isometric force of the trunk extensor and flexor muscles (MVC_E, MVC_F), weight distribution of the body (WD), handgrip strength (HGS), maximal oxygen uptake (VO_2max), lactate threshold (L) and heart rate (HR).

RESULTS: Mean force in MVC_{LP} was 1887(±455) N, MVC_{KE} right/left 633(±134)/628(±138) N and MVC_{KF} right/left 420(±79)/411(±74) N, respectively. CMJ height was 19.8(±3.9) cm and trunk forces in MVC_E 51.2(±13.7) kg and MVC_F 61.3(±11.4) kg. Mean WD in the right/left side was 50.5(±2.2)/49.5(±2.2) % and mean HGS of the right/left hand 39.9(±5.1)/39.2(±4.9) kg, respectively. Mean VO_2max in the cycle ergometer test was 32.1(±4.5) ml/kg/min, HR_{max} 184.5(±9.6) beat/min, $time_{max}$ to exhaustion 18.50(±2.50) min and L_{max} 10.2(±2.1) mmol/l.

CONCLUSIONS: SJ and E groups did not differ significantly from each other in any of the variables. MVC_{LP}, MVC_E and MVC_F were at about the same level but VO_2max somewhat below compared to non-athletic Finnish women of the same age. It would seem that the present female riders would obtain benefits from additional strength training for both maximal and explosive strength gains.

Key words: Equestrian sports, horseback riding, strength training, endurance training, combined strength and endurance training

TEXT

Introduction

Horseback riding has been used for transport of humans for thousands of years. Over the centuries, riding has evolved into a wide range of hobby and competitive sports. Riding has been in the Olympic Games continuously since 1912. The Olympic Games include show jumping, dressage and eventing. Riding is one of the few sport events in which men and women compete equally in the same competitions and riding classes. At the lower competition level, women are the majority in competitions, while top competitors are mostly men[1]. Equestrian sport is amongst the top ten most popular sports in Finland making riding the second largerst female participation sport in Finland[2 3].

Equestrian sports requires two athletes - human and horse - to move together harmoniously. An experienced rider can follow the motion of the horse and influence the speed, direction, and activity of the horse with her/his stabilized and coordinated body.[4] The systematic training of riding requires versatile information on physical performance capabilities and the type and level of riding specify the content of the physical fitness profile of the rider.

Heart rate and oxygen uptake of the rider increase as the gait speed of the horse increases[5-10]. A technically skilled rider can ride more economically. Maximal oxygen uptake (VO_2max) of international level female riders is on average slightly under 50 ml/kg/min[5 6], and those of a national level slightly under 44 ml/kg/min[6] and of a collegiate level approximately 34 ml/kg/min[11 12].

The musculature of the rider must be balanced in terms of strength and power capacity and mobility in all riding situations. Differences in body strength, power and mobility affect the communication with the horse[13]. The optimal requirement for strength levels of riders is uncertain. Westerling[6] measured maximal voluntary isometric muscle force of knee extension, hip adduction, elbow flexion and hand grip strength of experienced female riders (R) compared to the healthy, moderately physically active female non-riding control (C) sample. No significant differences were observed in strength levels between R and C. Alfredson et. al.[14] found significantly greater isokinetic concentric and eccentric thigh strength levels of female riders compared to non-active control subjects. Meyers & Sterling[11] and Meyers[12] have reported about similar upper body and abdominal strength in young female horseback riders compared to young non-riding females. According to Meyers[11] hand grip strength was consistently lower compared to female athletes of the right (28.9±6.9 kg) and left (26.7±6.3 kg) hand, but compared to non-riding females of the same age, hand grip strength levels were at about the average level[15]. Several studies have come to the conclusions that the rider needs to perform physical training without a horse. Riding only is not sufficient to maintain physical performance capacity of a rider at the required level[6 11 16-18].

The purpose of the present study was to examine the overall physical fitness profile of female riders. We measured endurance performance by recording also maximal oxygen uptake, maximal and explosive force production of the lower and upper extremities and trunk muscles as well as balance performance variables in female riders.

Materials and methods

Participants

52 Finnish female horseback riders volunteered to participate in the study. 19 of them were show-jumping riders (SJ) and 33 eventing riders (E). Physical characteristics (Mean ± SD) of female horseback riders of this study are presented in table I. The participants rode a minimum of 4 times / week their own or rented horse with the jumping level of minimum 1.06 ± 0.11 m. The informed riding level of the participants were from the national to the international. The participants were free of acute and chronic illnesses. All participants filled out a health questionnaire used by the University of Jyväskylä. Resting ECG was analyzed and approved by a cardiologist as a part of the pre-screening process. The selected subjects received detailed information about the study design, measurements and procedures and gave written informed

consent prior to participation. This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Ethics Committee of the University of Jyväskylä on October 20, 2016.

Experimental design

Force and endurance performance measurements

A familiarization session was carried out before the actual strength and endurance measurements. All measurements were performed in the same testing session in the order described below respectively.

Bilateral isometric leg press force (MVC_{LP}): Maximal bilateral isometric force (N) was measured using a horizontal dynamometer (designed and manufactured by the Department of Biology of Physical Activity, University of Jyväskylä, Finland) at the knee angle of 107° (180˚ = knee fully extended)[19]. Participants were instructed to produce maximum force as rapidly as possible against the force plate for a duration of 2-4 sec. Participants were verbally encouraged to perform their maximal. A minimum of three up to five trials were used to determine the maximal isometric leg press force with one minute break separating the trials. Isometric force signals were passed in real-time to the analog-to-digital (AD) converter (Micro 1401, Cambridge Electronic Design, UK). The trial with the highest peak force was selected for further analysis. Force signals were sampled at 2000Hz and low-pass filtered (20 Hz).

Unilateral isometric knee extension (MVC_{KE}) and flexion forces (MVC_{KF}): Maximal voluntary isometric unilateral force of the knee extensors and flexors of the right and left leg were measured in a sitting position at the knee angle of 107° (180˚= knee fully extended). The participants were secured in a sitting position in the modified knee extension and flexion device (David 200; David Health Solutions Ltd., Helsinki, Finland) with the safety belt in the hip area. The correct position was ensured by the adjustable back support, lever arm and ankle pad. Participants were instructed to produce maximum force rapidly against the ankle pad and maintain it for 2-4 sec. A minimum of three up to five trials were used to determine the maximal isometric forces with a one-minute resting period separating the trials. The trial with the highest peak force was taken for further analysis. The force signal was sampled at 2000Hz, low-pass filtered (20 Hz) and analyzed (Signal 4.10, Cambridge Electronic Design Ltd., Cambridge, UK).

Counter movement jump (CMJ): In the starting position the feet were parallel at a distance equal to the width of shoulders in a balanced upright position, keeping the trunk as vertical as possible and the hands on the hips throughout the test and the knee angle at 180 degrees. The contact platform (ErgoJump Bosco System) was used to record the height of the jumps. This device was a conductor carpet (dimensions L-175 x W-70 cm) connected to the electronic timing system. The timer switches on automatically when a subject takes off and switches off at the time when the feet make contact with the plate again. Microprocessors (Psion Organizer II © Datapak 32 k) were used to record the data collected from the platform through an external connection and ErgoJump Bosco System software$^{©}$.

Maximal isometric force of the trunk extensor and flexor muscles (MVC_E, MVC_F) was measured using the trunk dynamometer (designed and manufactured by the Department of Biology of Physical Activity, University of Jyväskylä, Finland). The participants were secured in a standing position in the trunk extension and flexion device with the safety belt in the hip area. The correct position was ensured by the adjustable chest (flexion) or shoulder (extension) and hip support. The upper extremities were relaxed near to the body. Participants were instructed to produce maximal force rapidly against the chest or shoulder pad and maintain it for 2-4 sec. A minimum of three to five trials were used to determine maximal isometric trunk extension and flexion forces with a one-minute resting period separating the trials. The trial with the highest peak force was used in the statistical analyses.

Weight distribution of the body (WD) was measured using the Good Balance force platform (Metitur Ltd, Jyväskylä, Finland; www.Metitur.com). Each subject stood in the riding position (jump seat) on the balance force platform and legs 50 cm apart. Knee and hip ankle were self-selected. Distribution of the weight was analyzed as percentage (%) of the left and right side.

Hand Grip Strength (HGS) was measured in both hands using a dynamometer (Smedley Hand Dynamometer, Stoelting Co, Wood Dale, Ill). Participants were instructed to produce maximum force and to maintain it for 2-4 sec. The measurement was repeated three times per hand. Hand Grip Strength was analyzed as kg of the left and right side. The best results of both hands were used in the statistical analyses.

***Maximal oxygen uptake (VO_2max)*:** Subjects underwent the continuous, incremental test to volitional exhaustion on the Monark cycle ergometer (Ergomedic 839E, Monark Exercise AB, Vansbro, Sweden). The measurement was terminated when subjects could no longer keep the rpm at 60. The test was initiated at an initial power output of 50 W. After a 3 min warm-up period the increments of 25 W were made every 3 min until exhaustion. The blood lactate levels (L) were measured at the end of each load, including warm up and 3x3 min recovery of 50 W according to the test protocol of the University of Jyväskylä. Heart Rate (HR) was measured in the end and beginning of each load using Polar H1 Heart Rate monitors (HRM, Polar Electro OY, Kempele, Finland). Maximal oxygen uptake was measured by the Oxycon Mobile® (OM) (Jäger, Würzburg, Germany). Oxygen uptake was measured during the cycle ergometer for every second by OM and results were averaged for each 30-second period. The highest averaged 30-second VO_2 value after exhaustion was registered as VO_2max. OM is the portable spirometric device consisting of a transducer holder with a turbine inside attached to a face mask. The rotation of this turbine is detected optoelectrically and allows the determination of minute ventilation. OM measures the oxygen concentration through an electrochemical sensor and data are transmitted telemetrically and recorded on a personal computer. During exercise, the battery-operated OM can be strapped to the back of the subject and it allows continuous data sampling[20 21].

Statistical analysis

Descriptive data were generated for all variables and expressed as mean, maximum, minimum and average ± SD. The analysis was performed using the Statistical Package for Social Sciences (SPSS version 22, Chicago, IL) and Microsoft Excel Programme (Version Plus 2016, Microsoft Corporation, Redmond, WA, USA). The statistical significance between two groups (Student´s t-test) was accepted when $p < 0.05$. Pearson correlation coefficients were calculated. The analysis was performed using the Statistical Package for Social Sciences (SPSS version 22, Chicago, IL).

Results

In the maximal cycle ergometer test VO_2max of the total subject group was 32.1 ± 4.5 ml/kg/min and total cycling time ($Time_{max}$) was 18.50 ± 2.50 min with no significant difference between two subject groups (Table II). HR_{max} of the total group measured immediately after exhaustion was 184.5 ± 9.6 bpm and the maximal blood lactate value after the test was 10.2 ±

2.1 mmol/l (Table II). There were no statistical differences in the cycle ergometer test values between the SJ or E groups. The isometric forces levels of trunk extensor and flexor muscles and grip strength in the SJ and E groups were very similar with no significant differences between the subject groups (Table III). Maximal isometric bilateral leg press force and maximal unilateral knee extension and flexion forces were also similar between the two subject groups (Table IV). Mean countermovement jump height in the total group was 19.8 ± 3.9 cm with no significant difference between two subject groups. Mean weight distribution of the body on the force platform balance test in the total subject group was 50.2 ± 3.1 % of the left and 49.8 ± 3.1 % of the right side.

Maximal isometric bilateral leg press force per body weight correlated significantly between countermovement jump height in the total group ($r=0.40$, $p<0.01$) (Figure 1). A significant correlation was found also between counter movement jumping height and maximal unilateral knee extensor force per body weight of the right ($r=0.51$, $p<0.01$) and left leg ($r=0.56$, $p<0.01$).

Discussion

The present results showed that national/international level Finnish female horseback riders had low to average levels of lower body strength. Maximal bilateral isometric leg press force (1887 ± 455 N) in our national/international level female horseback riders was slightly lower than physically active Finnish women (≈2000 N) of the same age[22 23]. Maximal unilateral isometric force of knee extensor muscles our riders was approximately at the same level (right 633 ± 134 N, left 628 ± 138 N) compared to untrained Finnish women (≈ 600 N) at about the same age[24]. Westerling[6] measured isometric muscular strength in equestrians as a maximal voluntary isometric contraction during knee extension in the right side of the body. There were no significant differences between the experienced female equestrians and the non-riding moderately physically active female control group. Alfredson et al.[14] reported higher strength levels of thigh strength in young female horseback riders measured by isokinetic concentric and eccentric dynamometer compared to non-riding secondary high school female students. Average force produced in 500 ms in the leg press in the present total group of riders was slightly under and maximal RFD clearly under those compared to physically active middle-aged Finnish women[22 25]. The rider steers and balances herself in the saddle by the lower limbs, and especially in the light seat used mainly for jumping parts of show jumping and eventing riding. Horse is an escaping animal[4] setting also requirements for the rider in terms of strength levels and reaction capability. However, it is still unclear what the level of force is in the lower limbs that produces the best performance in different species of riding.

The present results also suggest the importance of maximal strength in relation to body weight. Significant correlations were found between maximal bilateral isometric leg press and unilateral knee extension force per body mass and countermovement jumping height in the total group (Figure 1). It is probably beneficial that strength levels of riders are high - especially in relation to the body weight, since it contributes to greater explosive force production of the legs in the jumping performance and useful during the actual riding action.

The horse is mainly steered by the middle body of the rider. Rider can communicate with horse by minor chances in the place of middle body (position) on the saddle. The goal of a good position with good posture should be in balance with the horse, where the center of mass is equal to the horse[4]. Mean isometric force of trunk flexors in the total group was within the average range and that of extensors within the low range between our female horseback riders and non-athletic Finnish people of the same age (flexors ≈ 50 kg, extensors ≈ 70 kg)[26]. The flexion-extension force ratio in the present total group of subjects was 0.8±0.2. Westerling[6] reported force levels of trunk flexion and extension muscles in experienced female riders, and there was no difference in the results for the non-riding moderately physically active female controls. Meyers & Sterling[11] used the curl up and reverse sit up tests measuring muscular endurance strength of the abdominals and back muscles in female equestrian students. They reported above average results of abdominals and average results of back muscle strength according to Krause-Weber criteria for females in the same age group. Meyers[12] used The Robertson Modified Curl-Up test to measure abdominal muscle strength and the reverse sit-up tests measuring the back muscles levels of female equestrian students and randomly recruited controls. Abdominal muscle strength was somewhat below and the back muscles were at about the same level between equestrian students and the randomly recruited controls. All of the present reports show that force levels of trunk flexors and extensors of horseback riders are quite similar compared to non-athletic women of the same age. It would seem that there is some imbalance between abdominal and back muscle levels of force in the present female horseback riders.

Mean isometric grip strength values of the right and left hand in the present total group of female horseback riders were clearly above the average level compared to non-athletic women of the same age (27.7 - 29.0 kg)[27]. Westerling[6] reported also high hand grip strength values of the right hand in experienced female riders. Meyers & Sterling[11] reported the results of hand grip strength in both left and right hands of female equestrian students and it would seem that more advanced riders would obtain higher results of the hand grip strength than novice riders. It is important that hand grip strength levels are similar between both hands, because the feel of the horse's mouth by reins must be kept steady and stable in both sides of the horse’s mouth and bit. Inequality of the hands may affect the manageability of the horse.

Mean VO_2max of the present female horseback riders was measured by the cycle ergometer test. The maximal oxygen uptake in the present female horseback riders (32.1±4.5 ml/kg/min) was below average compared to women of the same age according to the reference values of Shvartz & Reibold[28]. Westerling[6] also used the cycle ergometer test and reported higher VO_2max levels in elite female riders (48-58 ml/kg/min) compared to ~~the~~ experienced female riders (43.8±4.0 ml/kg/min). Meyers[12] measured maximal oxygen uptake of female equestrian college students using a treadmill protocol and reported a mean VO_2peak value of 33.4±1.2 ml/kg/min. Meyers & Sterling[11] reported similar values in female equestrian students (33.9±4.5 ml/kg/min). Similar findings have also been found in a few other studies[6 16 17]. It would appear that maximal oxygen uptake increases in proportion to the riding level. According to Wassermann[29] we should note that in the treadmill test higher VO_2max values are obtained compared to the bicycle ergometer test values. The number of working muscles is higher in the treadmill versus the bicycle ergometer test, whereby the level of VO_2max increases. Meyers[12] and Douglas[18] noted that riding did not elicit an aerobic component suitable for enhancing cardiorespiratory fitness. Earlier studies showed that top-level riders engage in other sports than horseback riding[6 17]. However, it is unclear what type of training the horseback rider will benefit the most.

The focus of horseback riding is typically on training by riding with horses. Commonly, horseback riding is the only way to practice physical performance characteristics of a horseback rider[11]. However, riding is a sport where the strength balance of the muscles and well balanced body, clearly and exact timed movements of the body and limbs (aids of rider)[4] and the economy of riding performance[10] are relevant to the success of the riding performance. Good physical performance of the rider also supports of horse welfare. Several studies have shown that the horseback riders strength and endurance properties are mainly at the same level or somewhat lower than the average compared to non-athlete women of the same age[6 11 16-18].

It seems that higher force levels accompanied by lower body weight would give preferable performance characteristics of riders. The horse has the advantage that the rider is lightweight, while at the same time powerful in terms of maximal and explosive strength. Explosive strength with a proper balance of the musculature of the total body can generate rapid actions and explicit aids, which is beneficial when communicating with a horse. Balanced force per body mass has a positive effect on minimizing fatigue and an economical rider can utilize more of their riding skills.

Conclusions

Female riders would benefit of additional maximal and explosive strength training and, on the other hand, of somewhat reduced body weight to reach a better physical fitness profile in relation to body weight.

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NOTES

Conflicts of interest. The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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TABLES

Table I. Physical characteristics (Mean±SD) of female horseback riders in the total group of subjects and in two subject groups separately.

Variable	**All (N=52)**	**Eventing (n=33)**	**Show Jumping (n=19)**
Age (yr)	29.4 ± 8.9	31.5 ± 8.4	25.7± 8.6
Height (cm)	168.0 ± 6.1	167.4 ± 6.1	169.0 ± 6.2
Body mass (kg)	67.5 ± 10.0	67.6 ± 10.2	67.4 ± 9.9
BMI (kg/m^2)	23.9 ± 3.5	24.1 ± 3.5	23.6 ± 3.4

BMI=Body Mass Index

Table II. Mean characteristics (Mean±SD) in the maximal cycle ergometer test in female horseback riders.

Variable	**All (N=52)**	**Eventing (n=33)**	**Show Jumping (n=19)**
VO_2max (ml/kg/min)	32.1 ± 4.5	31.7 ± 4.7	33.0 ± 4.2
HR_{max} (bpm)	184.5 ± 9.6	183.3 ± 9.4	186.5 ± 9.7
$Time_{max}$ (min)	18.50 ± 2.50	18.53 ± 9.40	18.45 ± 2.20
L_{max} (mmol/l)	10.2 ± 2.1	10.1 ± 1.8	10.5 ± 2.7
$L_{recovery1}$ (mmol/l)	10.3 ± 1.7	10.5 ± 1.8	9.9 ± 1.5
$L_{recovery2}$ (mmol/l)	9.2 ± 2.1	9.3 ± 2.2	9.0 ± 1.9
$L_{recovery3}$ (mmol/l)	7.6 ± 1.8	7.8 ± 1.9	7.2 ± 1.7

VO_2max = Maximal oxygen uptake, HR=Heart Rate, L=blood lactate

Table III. Mean isometric forces (Mean±SD) of trunk flexors and extensors and grip strength in female horseback riders.

Trunk Force (kg)	**All (N=52)**	**Eventing (n=33)**	**Show Jumping (n=19)**
Trunk flexion force	51.2 ± 13.7	51.8 ± 14.1	50.2 ± 13.3
Force/body mass	0.8 ± 0.2	0.8 ± 0.2	0.7 ± 0.2
Trunk extension force	61.3 ± 11.4	61.6 ± 12.3	60.8 ± 10.0
Force/body mass	0.9 ± 0.2	0.9 ± 0.2	0.9 ± 0.1
Flexion-extension ratio	0.8 ± 0.2	0.9 ± 0.2	0.8 ± 0.2
Grip Strength (kg)	**All (N=52)**	**Eventing (n=33)**	**Show Jumping (n=19)**
Right (R)	39.9 ± 5.1	39.7 ± 5.6	40.2 ± 4.2
Left (L)	39.2 ± 4.9	39.5 ± 5.2	38.7 ± 4.4

Table IV. Maximal isometric force and force-time variables in bilateral horizontal leg press and in unilateral knee extension and flexion in female horseback riders.

Characteristics	**All (n=52)**	**Eventing (n=33)**	**Show Jumping (n=19)**
Leg Press (bilateral)			
Max force (N)	1887 ± 455	1873 ± 500	1912 ± 376
Force/body mass	2.9 ± 0.6	2.8 ± 0.7	2.9 ± 0.4
Average force 0-500 ms (N)	1235 ± 312	1232 ± 336	1242 ± 273
Time to 50 % of max force (ms)	130 ± 43	127 ± 41	134 ± 48
RFD-max ($N \cdot s^{-1}$)	10115 ± 3560	10158 ± 3583	10038 ± 3616
Knee extension right (R) unilateral			
Max force (N)	633 ± 134	638 ± 154	625 ± 91
Force/body mass	1.0 ± 0.2	1.0 ± 0.2	1.0 ± 0.2
Average force 0-500 ms (N)	431 ± 128	442 ± 119	411 ± 144
Time to 50 % of max force (ms)	110 ± 83	98 ± 54	132 ± 117
RFD-max ($N \cdot s^{-1}$)	7157 ± 3410	6969 ± 3388	7485 ± 3517
Knee extension left (L) (unilateral)			
Max force (N)	628 ± 138	645 ± 156	598 ± 98
Force/body mass	1.0 ± 0.2	1.0 ± 0.2	0.9 ± 0.2
Average force 0-500 ms (N)	428 ± 113	433 ± 124	419 ± 94
Time to 50 % of max force (ms)	116 ± 65	117 ± 68	114 ± 60
RFD-max ($N \cdot s^{-1}$)	6707 ± 3558	6562 ± 3510	6959 ± 3722
Knee flexion right (R) (unilateral)			
Force (N)	420 ± 79	427 ± 82	408 ± 74
Force/body mass	0.6 ± 0.1	0.7 ± 0.1	0.6 ± 0.1
Knee flexion left (L) (unilateral)			
Force (N)	411 ± 74	413 ± 73	407 ± 76
Force/body mass	0.6 ± 0.1	0.6 ± 0.1	0.6 ± 0.1
R-L difference (%)	2.7 ± 12.2	3.9 ± 13.4	0.7 ± 9.9

RFD= Rate of Force Development

FIGURES

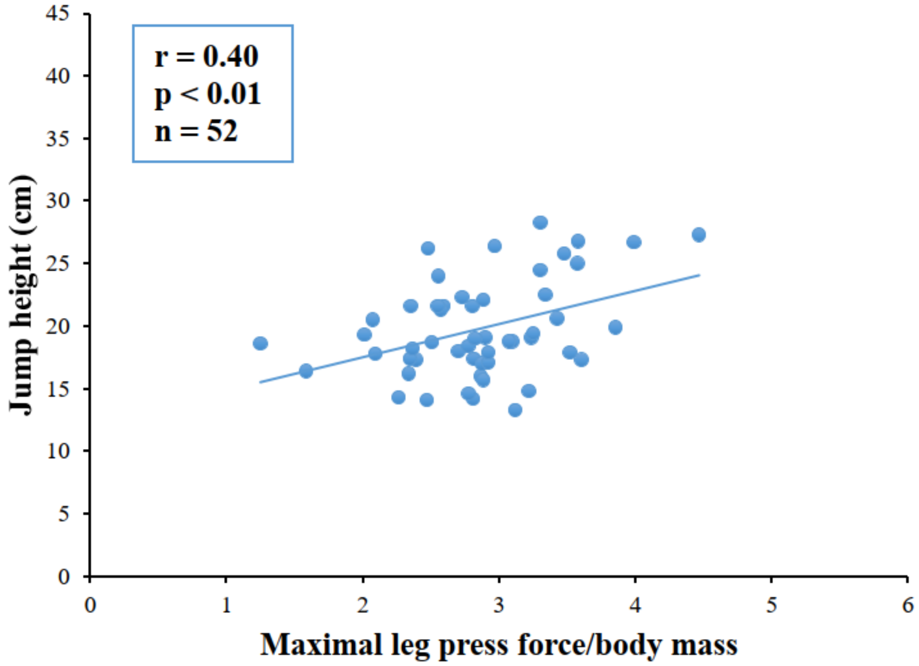

Figure 1. Relationship between maximal bilateral isometric leg press force per body mass and countermovement jumping height in the total group of female riders.