

The effect of chronic leg press exercises on hamstring muscle length and different vertical jump performance

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Abstract

Background and Study Aim As it is known, chronic resistance exercises cause limitations in some joints and this negatively affects the normal range of motion. In the present study, it was aimed to analyse the quadriceps-hamstring balance by analysing different vertical jump performances after six weeks of leg press exercise.

Material and Methods Eleven university students aged between 18-30 years were included in this study. The hamstring muscle length, 1 repetition maximum (1-RM) leg press performance were analysed before and after six weeks of leg press exercise. In addition, the vertical jump performances of the participants were analysed with My Jump 2 software programme. In this study, counter movement jumps (CMJ) and squat jump (SJ) performances of the participants were determined.

Results According to the findings, 1 repetition maximum (1-RM) leg press performance and hamstring length of the participants improved significantly ($t=-7.609$, ES: -2.29 , $p<.001$; $t=-2.540$, -0.76 , $p=.029$, respectively). CMJ and SJ parameters of the participants did not change ($p<0.05$). It was concluded that the lengthened hamstring length after the leg press exercise programme had a positive relationship with vertical jump height ($r=0.656$, $p=0.028$), flight duration ($r=0.663$, $p=0.026$), speed ($r=0.657$, $p=0.028$), and average speed ($r=0.669$, $p=0.024$). These relationships were observed among CMJ parameters following the exercise programme. Likewise, a positive correlation was found between hamstring length, which lengthened after the leg press exercise programme, and vertical jump height ($r=0.625$, $p=0.040$), flight duration ($r=0.646$, $p=0.032$), speed ($r=0.646$, $p=0.032$), and average speed ($r=0.637$, $p=0.035$). These correlations were identified among the SJ parameters after the exercise.

Conclusions As a result, it was determined that chronic leg press exercises positively affected hamstring muscle length and muscle strength. Different vertical jump performances such as CMJ and SJ did not change. However, the relationship between hamstring length and vertical jump parameters is interesting.

Keywords: leg press exercise, hamstring length, vertical jump, strength, power

Introduction

It is commonly known that regular resistance training can improve muscle power and strength [1, 2]. On the other hand, it is also acknowledged that extended resistance training might result in joint restrictions [3], which may jeopardize appropriate range of motion and overall athletic performance [4]. The mismatch between the agonist and antagonist

muscle groups, specifically the hamstrings and quadriceps, is a significant component that can affect the effectiveness of movements and injury risk [5]. It is critical to comprehend how various muscle groups interact and how that interaction affects functional movement patterns in order to maximize training results and reduce the likelihood of musculoskeletal problems.

Although the quadriceps and glutes are the main muscles targeted by leg press exercises [6], the hamstring muscles are also important for supporting lower body motions [7]. Long-term resistance

training, like leg press workouts, can cause changes in the length and flexibility of muscles. However, the precise effect on the length of the hamstring muscles may differ based on variables including volume, intensity, and personal biomechanics. According to some research, extended leg press exercise may lengthen the hamstring muscles as the muscles become more flexible in response to the demands of the exercise [8]. On the other hand, insufficient stretches or inappropriate training methods may lead to a reduction in hamstring suppleness and an increased likelihood of injury [9]. Thus, for the purpose of maximizing musculoskeletal health and overall athletic performance, it is imperative to evaluate hamstring muscle length and to conduct suitable flexibility training programs in conjunction with leg press exercises.

By concentrating on the investigation of quadriceps-hamstring balance in the context of chronic leg press activities, the current study tackles this significant topic. Our specific goal is to find out how a six-week leg press exercise plan may impact various components of vertical jump performance – a trustworthy measure of lower limb strength and power. We want to clarify the dynamic link between quadriceps and hamstring muscles in response to resistance training by assessing many vertical jump performance metrics, such as jump height, velocity, and power output. The hypothesis of this study is engaging in a six-week chronic leg press exercise regimen will significantly enhance hamstring muscle length and 1-RM leg press performance in participants.

Materials and Methods

Participants

In our study, the minimum sample size was determined by G power software programme (version 3.1). Accordingly, when $\alpha=0.05$, power $(1-\beta)=0.80$ and effect size 0.9, it was determined that at least 10 participants should be included in the study. Accordingly, 11 male participants aged between 18-30 years were included in the study. Participants who had synovial deficits in the knee joint, meniscus problems, stayed away from sports due to muscle, bone or tendon problems in the last 1 year, or had existing infections were not included in the study.

Prior to this study, all participants signed the Informed Voluntary Consent form and were informed

about the purpose, duration and contribution to the literature. All procedures in the study were carried out in accordance with the principles determined in the Declaration of Helsinki. For this study, the necessary permissions were obtained from Inonu University Health Sciences Scientific Research and Publication Ethics Committee with approval number 5155.

Experimental Design of Study

After obtaining the demographic information of the participants who met the inclusion and exclusion criteria of the study, hamstring muscle lengths were analysed with the sit-and-reach test before the 6-week leg press exercise programme (Table 1) [10]. To determine the 1 RM leg press training load, the 1 repetition maximum (1-RM) values of all participants were calculated according to the Brzycki formula [11]. Counter movement vertical jump (CMJ) and squat jump (SJ) performances of the participants were performed with My Jump application. After the pre-tests were taken, a 6-week leg press exercise programme was applied. Then, post-tests were taken from all participants. Before the tests, the participants performed a 5-minute bicycle warm-up on a stationary bicycle. Participants were asked not to consume food and beverages other than water until at least 3 hours before the tests. All tests were taken in the Faculty of Sports Sciences Fitness Centre and the ambient temperature was between 20-22 degrees Celsius. All participants received instructions on how to perform the tests 24 hours before the tests (Figure 1).

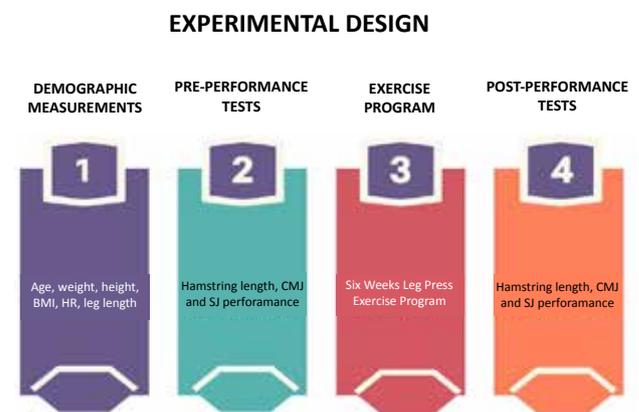


Figure 1. Experimental Design of Study

Procedures

Hamstring Length

The hamstring lengths of the participants were

Table 1. Six Weeks Leg Press Exercise Program

Weeks	Volume (sets ^x repetition)	Intensity (%1-RM)	Interval (s)	Eccentric time (s)	Concentric time (s)
1-2	3x10	70	60	2	1
3-4	3x8	80	80	2	2
5-6	3x6	90	105	2	2-3

1-RM: 1 repeated maximal

measured with the sit reach test. The sit reach test was performed according to the criteria of ACSM [12]. The participants placed their bare feet on the Seat and Reach brand platform. The knee joint was positioned in full extension and the ankle was positioned at 90 degrees. The participants pushed the metal placed on the platform and their maximum reach was recorded [13].

Vertical Jump Performance

The vertical jump performances of the participants were determined by CMJ and SJ. CMJ and SJ measurements were performed with My Jump 2, a smartphone application. Accordingly, 240 Hz videos of the participants were recorded with the help of iPad. In the recorded video, the take-off and landing frames of the participants were identified and defined in the literature;

$$h = t^2 \times 1.22625 \quad (1)$$

the flight time of the CMJ and SJ was calculated by converting this to a jump height using the equation [14]. During the CMJ performance, the individual was asked to start the jump in an upright posture, perform a forward fall movement with knee and hip flexion, then jump vertically upwards, and immediately and violently perform knee and hip extension to jump to the ground [15]. For the SJ measurement, the participants were asked to take a squat position with their knees flexed and jump upwards with maximum force with their hands on their waist [16].

Statistical Analysis

SPSS package programme 26 was used for statistical analyses in the study. Normality analyses of the data were determined according to Shapiro Wilk test and Skewness-Kurtosis values (-1.5+1.5). The data were found to be normally distributed and Paired Sample T test was applied for 1-RM, hamstring length, CMJ and SJ performance measurements before and after six weeks of leg press exercise. In the study,

R Studio (version 369) was used to determine the relationship between hamstring muscle length and vertical jump performances. Effect sizes of statistical analyses were calculated according to Cohen’s d formula [17]. The ES magnitude was defined as follows: <0.2= trivial, 0.2 to 0.6= small effect, >0.6 to 1.2 = moderate effect, >1.2 to 2.0 = large effect, and >2.0 = very large [18]. The significance level in the study was determined as 0.05.

Results

Table 2 shows the demographic information of the participants. Accordingly, the mean age of the participants was 20.81±3.25 years, body weight was 74.53±14.70 kg, height was 178.28±10.04 cm, and BMI was 23.34±3.49 kg/m².

In Table 3, leg circumference, 1-RM, and sit reach test results of the participants before and after leg press exercises were analysed. Accordingly, leg press 1-RM strength [t=-7.609, p<.001, ES=-2.29, (-3.43 to -1.12 95% CI)] and hamstring length results [t=-2.540, p=.029, ES=-.76, (-1.42 to -0.07 95% CI)] increased significantly after the six-week leg press exercise programme (Figure 2). Upper leg circumference did not change significantly after the exercise programme (p>.05).

In Table 4, the CMJ test results of the participants before and after the leg press exercise were analysed. According to this, vertical jump, flight time, speed, average speed, strength and power parameters of the participants did not change significantly (p>.05).

In Table 5, the SJ test results of the participants before and after the leg press exercise were analysed. According to this, vertical jump, flight time, speed, average speed, strength and power parameters of the participants did not change significantly (p>.05).

In Figure 3, the relationship between hamstring length and CMJ parameters of the participants before and after six weeks of leg press exercise is analysed. Accordingly, there was no correlation

Table 2. Demographic Information of Participants

Parameters	Mean	S.D.	Min	Max
Age (year)	20.81	3.25	18	30
Weight (kg)	74.53	14.70	56.80	103.3
Height (cm)	178.28	10.04	165.0	192.5
BMI (kg/m ²)	23.34	3.49	20.02	30.78

S.D.: Standard Deviation, BMI: Body Mass Index

Table 3. Examination of Performance Parameters of the Participants Before and After Leg Press Exercise

Parameters	Pre-Training Mean±S.D.	Post-Training Mean±S.D.	t-Value	ES	p-Value	%95 CI	
						Lower	Upper
Leg Circumference (cm)	53.54±5.49	54.99±5.16	-1.747	-.52	.111	-1.14	0.11
1-RM (kg)	182.21±41.59	240.28±62.14	-7.609	-2.29	<.001	-3.43	-1.12
Hamstring Length (cm)	14.54±7.87	17.00±8.65	-2.540	-.76	.029	-1.42	-0.07

1-RM: Repeat Maximum

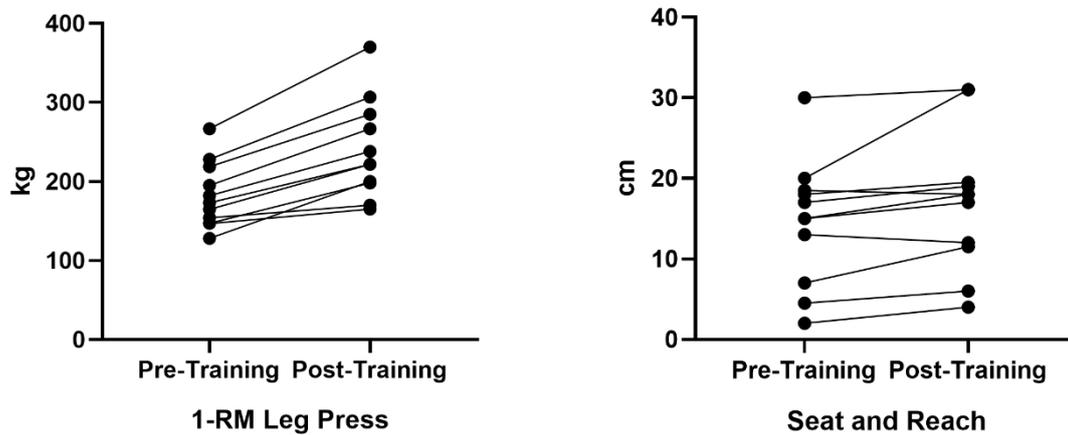


Figure 2. Participants’ 1-RM Leg Press and Sit Reach Test Results

Table 4. Comparison of CMJ test results of the participants

Parameters	Pre-Training Mean±S.D.	Post-Training Mean±S.D.	t-Value	ES	p-Value	%95 CI	
						Lower	Upper
Vertical Jump (cm)	44.45±9.04	43.73±6.35	0.612	0.18	.554	-0.41	0.77
Flight Duration (ms)	599.27±60.46	595.81±42.45	0.433	0.13	.674	-0.46	0.72
Speed (m/s)	2.93±0.29	2.92±0.20	0.396	0.11	.700	-0.47	0.71
Average Speed (m/s)	1.47±0.14	1.46±0.10	0.454	0.13	.659	-0.46	0.72
Strength (N/kg)	24.03±2.74	23.89±2.30	0.364	0.11	.723	-0.48	0.70
Power (W)	35.56±6.97	34.97±4.79	0.543	0.16	.599	-0.43	0.75

Table 5. Comparison of SJ test results of the participants

Parameters	Pre-Training Mean±S.D.	Post-Training Mean±S.D.	t-Value	ES	p-Value	%95 CI	
						Lower	Upper
Vertical Jump (cm)	36.10±7.60	37.20±6.73	-1.306	-0.39	.221	-1.00	0.23
Flight Duration (ms)	539.90±56.99	548.81±50.13	-1.396	-0.42	.193	-1.03	0.20
Speed (m/s)	2.64±0.28	2.69±0.24	-1.396	-0.42	.193	-1.03	0.20
Average Speed (m/s)	1.32±0.13	1.34±0.12	-1.515	-0.45	.161	-1.07	0.17
Strength (N/kg)	21.31±2.12	21.76±2.27	-1.565	-0.47	.149	-1.08	0.16
Power (W)	28.39±5.31	29.42±5.16	-1.429	-0.43	.184	-1.04	0.19

between the participants’ initial hamstring length and CMJ performance. However, it was concluded that the lengthened hamstring length after leg press exercise programme had a positive relationship with vertical jump height ($r=656$, $p=.028$), flight time ($r=663$, $p=.026$), speed ($r=657$, $p=.028$) and average speed ($r=669$, $p=.024$) among CMJ parameters after the exercise programme.

In Figure 4, the relationship between hamstring length and SJ parameters of the participants before and after six weeks of leg press exercise was analysed. Accordingly, no correlation was found between the participants’ baseline hamstring length and SJ performance. However, a positive correlation was found between the length of hamstring after the leg press exercise programme and SJ parameters such

as vertical jump height ($r=625$, $p=.040$), flight time ($r=646$, $p=.032$), speed ($r=646$, $p=.032$) and average speed ($r=637$, $p=.035$).

Discussion

The present study aimed to elucidate the effects of a six-week chronic leg press exercise regimen on hamstring muscle length and its subsequent impact on vertical jump performance. The significant improvement in 1 repetition maximum (1-RM) leg press performance and hamstring muscle length after six weeks of leg press exercises suggests that resistance training positively impacts muscle strength and flexibility. The impact of chronic resistance training on muscle strength, flexibility,

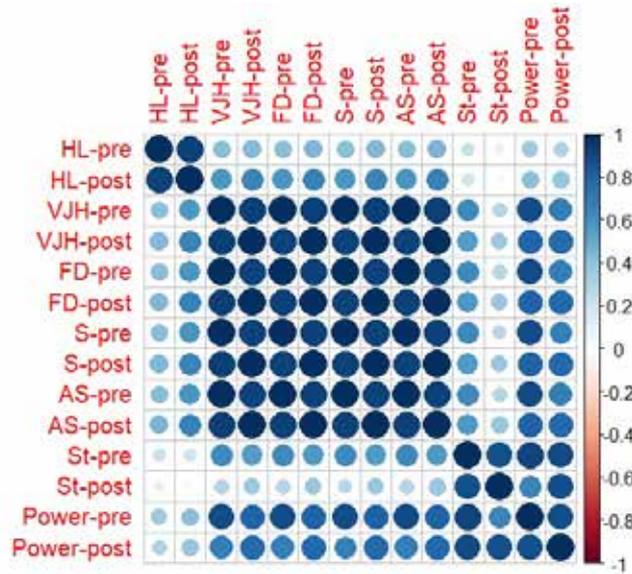


Figure 3. Correlation between hamstring length and CMJ parameters: HL: hamstring length, VJH: vertical jump height, FD: flight duration, S: Speed, AS: average speed, St: Strength

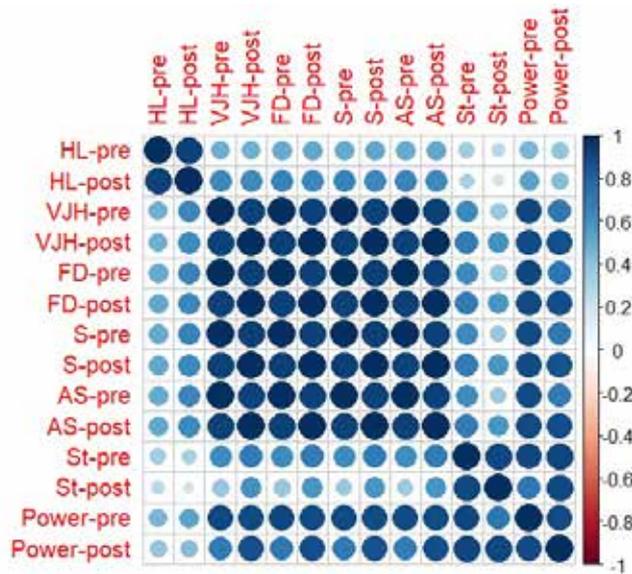


Figure 4. Correlation between hamstring length and SJ parameters: HL: hamstring length, VJH: vertical jump height, FD: flight duration, S: Speed, AS: average speed, St: Strength

and joint range of motion has been the subject of a systematic review and meta-analysis. The review found that resistance training with external loads can improve range of motion to a moderate magnitude, and that additional stretching prior to or after resistance training may not be necessary to enhance flexibility [4, 20, 21]. The study also highlighted that resistance training can be as effective as stretch training to increase joint range of motion [21]. The literature supports the existence of a “strength zone” for increasing one-repetition maximum (1RM), consistent with the concept of a repetition continuum [22]. Furthermore, it was noted that resistance training increases muscle strength by making the muscles work against a weight or force, and the optimal range for improving

muscle strength is 8–12 repetitions [23]. Therefore, the evidence suggests that chronic resistance training can have a positive impact on muscle strength, flexibility, and joint range of motion [4, 20, 21]. This finding is particularly noteworthy as it contradicts the common perception that chronic resistance exercises might limit joint flexibility and subsequently decrease the range of motion.

The lack of significant changes in CMJ and SJ performances, despite improved hamstring length and muscle strength, is an intriguing outcome. This could be interpreted in several ways. Firstly, vertical jump performance is multifactorial, depending heavily on factors like muscle power, coordination, and neural activation, beyond just muscle strength and length. The specificity of training principle also

comes into play, suggesting that improvements in a particular exercise or movement (like the leg press) may not directly translate into performance enhancements in a mechanically different movement (like vertical jumps). But there are some researches that revealed different results. Vertical jump performance is multifactorial and can be improved through various strength training methods. Weight training has been shown to improve vertical jumping performance in most cases by 2-8 cm or 5-15% [22, 23]. Exercises such as squats, lunges, leg presses, and toe raises with heavy loads (80-90% 1-RM) and low repetitions (4-6) are used to improve maximal strength [23, 24]. Plyometric exercises, such as depth jumps, have also been shown to improve vertical jump performance [25].

Moreover, the positive correlation between increased hamstring length and various CMJ and SJ parameters post-exercise (including vertical jump height, flight duration, speed, and average speed) is particularly intriguing. This correlation indicates a potential link between enhanced muscle flexibility and improved performance metrics within the jumps, even though the overall jump performance did not change significantly. This might suggest that while the overall power and ability to perform vertical jumps may not have been impacted, the quality and certain aspects of the jumps could have been subtly enhanced by the improved muscle function. The positive correlation between increased hamstring length and various countermovement jump (CMJ) and squat jump (SJ) parameters post-exercise, such as vertical jump height, flight duration, speed, and average speed, suggests a potential link between enhanced muscle flexibility and improved performance metrics within the jumps. While the overall power and ability to perform vertical jumps may not have been impacted, the quality and certain aspects of the jumps could have been subtly enhanced by the improved muscle function. Research has shown that the hamstrings-to-quadriceps ratio (H/Q ratio) is related to variables that describe CMJ and DJ (drop jump)

heights. A study found that the heights of CMJ and DJ were increased with higher H/Q ratios, indicating a positive relationship between muscle torque and vertical jump performance [24-26]. Another study evaluated the relationship between lower extremity strength, symmetry, and jump performance. It found that there is no negative or positive relationship between inter-limb isokinetic knee strength symmetry angle and jump performances, suggesting that strength symmetry may not significantly impact jump performance [27]. Additionally, a study on predictors of vertical jumping capacity in soccer players aimed to evaluate how isokinetic strength of the thigh muscles is related to jump performance. While the specific relationship to hamstring length is not mentioned, the study provides insights into the relationship between muscle strength and jump performance [28].

There are some limitations in this study. The small sample size and the specific demographic (university students aged 18-30) may limit the generalizability of the results. Future studies with larger, more diverse populations and extended training durations are recommended to validate these findings. Additionally, incorporating a control group and other forms of exercises could provide a more comprehensive understanding of the relationship between resistance training, muscle characteristics, and jump performance.

Conclusions

In conclusion, the study provides valuable insights into the adaptive changes in hamstring muscle characteristics following a chronic leg press exercise regimen and how these changes correlate with vertical jump performance. The findings highlight the complexity of translating muscle strength and flexibility improvements into performance enhancements in different athletic movements. Further research in this domain is essential to fully elucidate these relationships and to optimize training protocols for enhancing performance in jump-related sports and activities.

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