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Exploring the Correlation Between Hamstring Strength and Vertical Jump Performance Among Firefighters

Aulya Safiyna Nuuril Anwari[1], Achmad Widodo[1], Soni Sulistyarto[1], Awang Firmansyah[1]

[1]*Ilmu Keolahragaan /Fakultas Ilmu Keolahragaan dan Kesehatan, Universitas Negeri Surabaya, Indonesia*

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Abstract

Firefighting is a physically demanding occupation requiring high levels of muscular strength and power to perform tasks such as victim rescue, stair climbing, hose dragging, and equipment handling under unpredictable and hazardous conditions. This study aimed to examine the relationship between hamstring muscle strength and countermovement jump performance in firefighters. This study employed a quantitative cross-sectional design. Participants were active-duty firefighters who met the inclusion criteria. Total the participants are 43 with male gender, the body weight of 73,83 ± 10,38 kg, height of 172,44 ± 4,68 cm, Body Mass Index (BMI) was 24,79 ± 3,13 kg/m² . The results showed a significant relationship between hamstring muscle strength and countermovement jump power. The correlation between L Max Force and jump power was statistically significant (p = 0,002), as was the relationship between R Max Force and jump power (p = 0,001), both below the significance threshold of <0,05. These findings indicate that greater hamstring muscle strength is associated with higher CMJ power output. In conclusion hamstring muscle strength is significantly related to lower-limb explosive performance in firefighters.

Keywords: *Hamstring muscle strength, jump power, physical fitness, firefighters*

INTRODUCTION

Firefighting is a profession that often involves heavy and challenging work, requiring firefighters to always be ready to respond to emergencies. Some emergencies that occur at fire sites require firefighters to exert a high level of physical energy, from lifting heavy equipment, evacuating victims, climbing buildings, and other rescue efforts that often require handling environmental stressors, such as high temperatures, physical hazards, and hazardous chemicals and

Correspondence author: Aulya Safiyna Nuuril Anwari, Universitas Negeri Surabaya, Indonesia
Email: aulyasafiyna27@gmail.com

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smoke (Chizewski et al., 2021; Smith et al., 2016). The workload of firefighters requires them to maintain good physical fitness in order to manage field conditions in various situations that are often unpredictable (Illahi et al., 2024; Ras et al., 2023, 2024).

The heavy workload of firefighters is unpredictable and varied, which can reduce physical performance, potentially endangering their safety and putting them at high risk of work-related physical injuries (Maryono & Herbawani, 2023; Seabury & McLaren, 2012). Low levels of physical fitness can lead to task overload because the mismatch between the physical demands of firefighting and physical fitness levels results in many firefighters experiencing fatigue, injury, and even death while on duty (Chizewski et al., 2021; Ras et al., 2022; Smith et al., 2013). Fatigue is the leading cause of death (27.1%) and the second leading cause of musculoskeletal injuries (21%) among U.S. firefighters (Haynes, 2017).

These job requirements demand physical fitness components that include muscle strength, speed, and endurance. In emergency situations, firefighters need to be able to run quickly, carry heavy equipment, or evacuate victims. In this case, muscle strength and running ability are very important for firefighters. One important component of running ability is lower leg muscle strength, including the hamstring muscles. Optimal hamstring muscle strength not only improves athletic performance but also contributes to injury prevention, particularly knee injuries and hamstring strains (Opar et al., 2015). In the context of firefighting, weak hamstring muscle strength can cause delays in movement, imbalance, and the risk of accidents while on duty. The hamstrings play a central role in various explosive activities such as running and jumping. Several studies have found a significant relationship between jumping ability and running performance at various distances and in various sports. A strong correlation was found between countermovement jump (CMJ) height and sprint time in athletes with CMJ potentially serving as a predictor (Lee & McGill, 2015; Struzik et al., 2017) .

Therefore, fitness programs and structured physical activities are strategies that firefighters can use to reduce injury risk factors. Given that there is a clear need for a level of fitness that is not only necessary for working efficiently, but also for reducing the likelihood of injury among firefighters. Emphasis on the importance

of physical components and specific fitness training programs designed to improve aerobic capacity and muscle strength is needed in order to reduce fatigue and the risk of injury while on duty. This study aims to examine the relationship between hamstring muscle strength and the jumping power of firefighters. The findings of this study can serve as an initial indicator for predicting critical needs in emergency tasks. The findings of this study are expected to provide a scientific basis for the development of functional physical training programs for firefighters.

METHODS

Design

This study uses quantitative descriptive research, because the data obtained in this study will be analyzed and interpreted. The design of this study uses a cross-sectional study. This approach was chosen with the aim of describing, explaining, and testing the relationship between the variables in this study using statistical analysis. This study is an analytical observational study that aims to determine the relationship between hamstring muscle strength and the jumping power of firefighters.

Participants

The participants were active-duty 43 male firefighters from the rescue team of the Surabaya City Fire and Rescue Department, aged 25–50 years. Participants were recruited using purposive sampling. Inclusion criteria were: (1) active operational rescue personnel, (2) minimum one year of service experience, and (3) medically cleared for physical performance testing. Exclusion criteria included lower-limb musculoskeletal injury within the past six months, diagnosed cardiovascular or neurological disorders, and current participation in rehabilitation programs. Prior to participation, all firefighter rescue team members signed a consent form stating their willingness to participate in the research and acknowledging the research information provided to them.

Data Collection

The firefighters underwent hamstring muscle strength tests and measurements using NordBord equipment from Vald Performance and peak power measurements using the Countermovement Jump test with Forcedecks equipment

from Vald Performance.

Data Analysis

The data obtained from the test will be collected and compiled into Microsoft Excel, then processed using Statistical Package for Social Science (SPSS) version 27 software for analysis using Pearson's correlation analysis $p<0.005$, which is used to find the relationship between two or more variables. Furthermore, the analyzed data will be described to provide an overview of the relationship between hamstring muscle strength and the jumping power of firefighters.

RESULTS

The descriptive statistics of the participants' general characteristics and performance variables are presented in Table 1. This table provides an overview of demographic data, anthropometric profile, and lower-limb performance measurements before the correlation analysis.

Table 1. Descriptive Characteristic of the partisipants

Variabel		Max	Min	Mean ± SD
Age (year)		49	25	32,86 ± 5,56
Weight (kg)		99,5	50	73,83 ± 10,38
Height (cm)		185	164	172,44 ± 4,68
BMI		33,6	17,5	24,79 ± 3,13
CMJ		4.493,00	2.285,00	3.522,04± 528,36
Nordic	Right	594,50	150,00	289,74 ± 68,15
	Left	422,50	149,50	270,59 ± 51,35

*SD: Standard Deviation; BMI: Body Mass Index (kg/m2); CMJ:

Countermovement Jump (W)

Table 1. presents the general characteristics of the participants, who were active-duty male firefighters from rescue team. The mean age of the participants was 32,86 ± 5,56 years, with an age range of 25-49 years, indicating a predominantly productive operational age group. Regarding anthropometric characteristics, the participants had a mean body weight of 73,83 ± 10,38 kg and a mean height of 172,44 ± 4,68 cm. The mean *Body Mass Index* (BMI) was 24,79 ± 3,13 kg/m², suggesting that most participants were within the normal to slightly overweight classification.For performance variables, the mean *peak power* obtained from the Countermovement Jump (CMJ) test was 3.522,04 ± 528,36 W. Hamstring muscle strength measured using the Nordic Hamstring test showed a mean peak force of 289,74 ± 68,15 N for the right limb and 270.59 ± 51.35 N for the left limb.

Based on the descriptive characteristics presented in Table 1, further analysis was conducted to examine the relationship between hamstring muscle strength and vertical jump performance. The results of the Pearson correlation analysis are presented in Table 2.

Table 2. Relationship between hamstring muscle strength and jump power

Variabel	Mean ± SD	P-Value
L Max Force	270,59 ± 51,35	0,002*
Jump Power (W)	3522,04 ± 528,36	
R Max Force	289,74 ± 68,15	0,001*
Jump Power (W)	3522,04 ± 528,36	

*significant p-value <0.05

The results of the correlation analysis in Table 2. show a significant correlation between hamstring muscle strength and jump power in firefighters. The p-values obtained for the correlation between L Max Force and Jump Power are p = 0,002, and for R Max Force and Jump Power p = 0,001; both are < 0,05, thus indicating a significant correlation. The average hamstring muscle strength of the left leg (L Max Force) was 270,59 ± 51,53 N and the right leg (R Max Force) was 289,76 ± 68,15 N, while the average jump power was 3522,04 ± 528,36 W. These

findings indicate that increased hamstring strength is associated with increased jump power in the sample studied.

DISCUSSION

The results of the study show a significant relationship between maximum isometric hamstring strength (both left and right) and vertical jump power in firefighters. These findings are consistent with the biomechanical hypothesis that the hamstrings contribute to jump power output during the push-off phase and hip or knee stabilization during the jump movement. The findings of this study are also in line with research conducted by Altundağ et al. (2024), which revealed a significant relationship between unilateral hamstring strength and corresponding leg vertical jump performance.

Biomechanically, the hamstrings play a role in hip extension and the transfer of force from the pelvis to the legs during the propulsive phase of the jump. The strength and ability to generate torque by the hip flexor muscles or hamstrings will increase the ability to generate explosive power. Additionally, the role of eccentric hamstring contraction supports increased jump height and power, which is consistent with research on the relationship between hamstring strength and jump performance (Ma et al., 2025; Struzik & Pietraszewski, 2019; Váczi et al., 2022)

Previous studies have found a relationship between hamstring muscle strength, H:Q ratio, or interlimb asymmetry and countermovement jump performance or other power variables. A previous study by Edbert et al. (2018) also showed that relative hamstring strength asymmetry can reduce jump performance or explosive speed. Hamstring exercise intervention (Nordic hamstring exercises) can increase hamstring strength and vertical jump height (Calero-Morales et al., 2025; Hosseini et al., 2025; Sammoud et al., 2026).

Jump power ability is important for firefighters in performing tasks that require rapid mobility, climbing, or jumping over obstacles. These findings support the recommendation of training programs that incorporate hamstring strength-building exercises, such as Nordic hamstring exercises, eccentric exercises, and functional weight training combined with plyometric training to improve explosive power generation. Hamstring training interventions have also been reported to improve vertical jump performance when combined with plyometric and strength

training programs (Potosí-Moya et al., 2025). Several interventions integrating strength training with plyometric modalities have been shown to enhance vertical jump performance. For example, programs combining targeted exercises for lower-limb strength with plyometric components produced significant improvements in countermovement jump height compared to control conditions, suggesting that the combination of muscular strength development and stretch-shortening cycle enhancement contributes to explosive jump performance (Luo et al., 2025; Paladino & Barriuso, 2021; Turan et al., 2025).

CONCLUSSION

Based on the results of this study, it can be concluded that there is a significant relationship between hamstring muscle strength and countermovement jump power in firefighters. Hamstring strength in both the left and right legs showed a positive correlation with the amount of jump power generated. These findings indicate that the greater the hamstring muscle strength, the greater the jump power generated. This is in line with the biomechanical role of the hamstrings in supporting hip extension and knee stability. Thus, strengthening the hamstring muscles can be considered an important component in training programs aimed at improving lower extremity explosive performance, especially for professions that demand high physical abilities such as firefighters, to prevent movement compensation and reduce the risk of injury while on duty.

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