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EFFECT OF QUADRICEPS MUSCLE STRENGTH, RANGE OF KNEE MOTION AND MOTIVATION ON STATIC BODY BALANCE IN PATIENTS POST ANTERIOR CRUCIATE LIGAMENT (ACL) RECONSTRUCTION

Ahmad Syafei[1*], James Tangkudung [1] , Junaidi [1]

[1] Physical Education, Postgraduate Universitas Negeri Jakarta, Universitas Negeri Jakarta complex Jl. Rawamangun Muka east Jakarta Indonesia 13320

Coresponding email : syafeibastian@gmail.com

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ABSTRACT The purpose of this research is the effect of quadriceps muscle strength, knee range of motion and motivation on static body balance in patients after anterior cruciate ligament (ACL) reconstruction. The target population of the study were all post-ACL reconstruction patients, which consisted of 30 patients at a special clinic for handling sports injuries at Physio IN Bekasi. Static body balance instrument (Y) using the Stork Stand Test. The quadriceps muscle strength instrument (X1) uses a quadriceps muscle strength test with a sphygnomanometer test. Range of motion (ROM) of the knee (X2) using a goniometer. Motivation (X3) uses a motivation test with a questionnaire, the questionnaire test is arranged according to the Likert scale. The result of this research is the direct effect of variable X1 on Y = 12.96%. The direct effect of the X2 variable on Y = 25.2%. The direct effect of the X3 variable on Y = 15.68%. The direct effect of the X1 variable on X3 = 19.8%. The direct effect of variable X2 on X3 = 6.86%. The indirect effect of variable X1 on Y through X3 = 28.75%. The indirect effect of variable X2 on Y through X3 = 36.7%.

Keywords: Quadriceps muscle strength; range of motion; motivation; static body balance

INTRODUCTION

Good performance is one of the absolute requirements that an athlete must have. In sports activities there are often movements that can cause excessive loading or trauma to a body tissue which further results in an injury (Kiapour & Murray, 2014).

Sports injury is trauma that occurs before, during and after sports activities, where sports injuries occur due to an imbalance between workload and network ability (Failla et al., 2016).

Sports injury is the occurrence of damage to the tissues in the bones, muscles, ligaments, nerves and skin during sports (Kiapour & Murray, 2014). One of the injuries that often occur in sports activities is ligament injury (Bartlett, 2007).

Types of sports injuries according to Chambat, (2013) Viewed from biomechanics and the mechanism is divided into traumatic and non-traumatic injuries. Trauma injuries is caused by direct contact with players or *direct blow*,thetype of injury most often caused by direct trauma in the form of contusio (bruising). Meanwhile, non-traumatic injuries are not caused by direct impact but are caused by movement errors during sports.

According to Majewski et al., (2006) The increasing popularity of the sport has been accompanied by an increasing number of injuries. Usually, the lower body often suffers injuries, especially knee injuries. The following include knee injuries, namely damage to the lateral collateral ligament (LCL), medial collateral ligament (MCL), anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), injury to the meniscus or joint bearing both lateral meniscus (LM) and medial meniscus (MM). Knee injuries clinically experience pain, swelling, *range of motion* disorders (ROM), decreased stability and meniscus damage. *Internal* knee injuries accounted for 44.8% of cases compared to all knee injuries, the incidence of internal knee injuries was 20.3% ACL injury, MCL 7.9%, LCL 1.1% and PCL 0.65%, MM 10.8%, LM 3.7% (Majewski et al., 2006).

The most common knee ligament injury is the rupture of the *anterior cruciate ligament* (ACL). An estimated 70% of ACL injuries are sustained through non-contact mechanisms, while the remaining 30% are direct contact mechanisms. Therefore, ACL injury can cause the knee joint to become unstable so that the tibia bone can move freely,

where the unstable knee is very vulnerable to the risk of other tissue injuries such as muscle injury around the knee and *meniscus* injury or knee joint pads (Atwi et al., 2017).

The incidence of injury to the ACL causes various problems in movement and body function, including injuries to other joints such as *ankle* and *hip,* injuries to the knee joint pads *(meniscus)* and imbalance of muscle strength to impaired walking function (Zein, 2013).

Conservative ACL injury management provides inadequate results, as the individual has instability problems when they return toexercise. Persistentknee instability will increase the disorder after the ACL injury (Alaa et al.,2018). Therefore, surgery is highly recommended for individuals who have ACL ligament injuries who have impaired knee stability.

Reconstructive surgery is the main treatment recommended after a collapse or rupture of the ACL ligament especially for athletes engaged in high-level sports activities in hopes of permanently reducing knee instability and rebuilding knee mechanics. Changes in the kinematics of the lower extremity joints at the time of walking have been reported in individuals who perform ACL reconstruction. In addition, there was a decrease in the scope of joint movement (LGS) of the knee and a decrease in the strength of the flexor and extensor muscles of the knee, a decrease in balance ability at the time of standing was reported in ACL reconstruction patients within the first year after surgery. (Hadizadeh et al., 2016).

Other problems caused after ACL reconstruction are the presence of motion pain, swelling due to inflammation or postoperative inflammation, decreased strength of flexor and extensor abdominal muscles, limited *range of motion* (ROM) so that it will cause difficulties at standing, impaired balance, walking function and return in sports activities. Muscle strength function, balance ability and good *range of motion* (ROM) are important components in supporting daily activities (Alshewaier et al., 2017). Neuromuscular control of the knee after injury or ACL reconstruction allows better outcomes to restore functional activity and reduce the occurrence of repetitive injuries. (Akbari et al., 2015).

According to Sofi Sonesson, Joanna Kvist, Clare Ardern, Annika Osterberg dan Karin Gravare Silbernagel

(2016) Anterior *cruciate ligament* (ACL) injury is common at a young age who is actively exercising (15-30 years). Patients have high hopes of recovery after ACL reconstruction, the majority of whom expect good knee function and return to exercise as before the injury. But these high expectations may not be met due to low patient motivation when attending an exercise program.

Romaniuc dan Bazart (2015) Motivation is a person's tendency to do something better or more influential. Good motivation allows a person to work better. (Maulana, Widiastuti, & Rihatno, 2020). Motivation is the drive for someone to do something to achieve a goal (Geta septiadi, Firmansyah Dliss, & Abdul Sukur, 2021).

Many athletes do not return to the level of the sport as before the ACL injury even though they are physically rehabilitated and despite the fact that the purpose of reconstruction and exercise programs is to restore to the level before the injury. The motivation of athletes or individuals who experience ACL injuries while participating in a rehabilitation program greatly affects the results of the exercise, such as increasing muscle strength, achieving maximum *range of motion*, reducing pain and achieving the targets of other exercise programs. Most patients (85-90%) report good knee function after ACL reconstruction, but less than half of patients return to competitive exercise as before the injury (Sonesson et al., 2016).

Balance is the ability that a person has in maintaining the center of the gravitational point of the pedestal field when the position is upright (Murti, Marani, & Rihatno, 2020). Kbalance is categorized into static and dynamic balance. Static balance is required when sitting or standing still. Dynamic impact is required when walking, running or moving from one point to another in a space (Ageberg et al., 2005). Dynamic balance is defined as the ability to switch from a dynamic state to a static state or the ability to maintain stability while performing dynamic movements (Kouvelioti et al., 2015).

According to Pengse po et al., (2017) Balance problems in patients after ACL reconstruction of both static and dynamic balance are found, where body balance is affected by several factors such as *quadriceps* muscle strength. Quadriceps muscle weakness almost occurs after injury and reconstruction of the anterior *cruciate ligament* (ACL). Strength deficits of

more than 30% in reconstructed limbs compared to contralateral limbs have been reported six months postoperatively, when patients often return to full activity. The presence of quadriceps muscle weakness *(quadriceps)* may be dangerous for the patient. Quadriceps muscles are important for controlling the lower extremities during dynamic activity and weakness of the thigh muscle canalter movement strategies that have the potential to cause re-injury.

Quadriceps muscle weakness occurs after immobilization of the knee joint and can cause weakness in the quadriceps muscle after injury and reconstruction of the ACL. Previously reported deficits of about 7% in the total volume of quadriceps muscles in reconstructed limbs compared to contralateral muscles in patients 6-12 months after ACL reconstruction (Pengse Po et al., 2017). In addition to quadriceps muscle weakness, balance or postural control is affected by the presence of impaired *range of motion knees* after ACL reconstruction.

According to Haro & Shelbourne (2016) The cause of loss or decrease in the scope of motion of the joint after ACL surgery occurs due to many factors and can decrease the motion of extension, flexion or both. However, the full loss of extension is usually more noticeable than the loss of knee flexion.

Loss of full knee extension is a potential problem, It is thought that the lack of symmetrical knee extension following ACL reconstruction is more dangerous than preoperative instability and that loss of knee extension is detrimental to the active population (Noll et al., 2015). Range of motion disorders can also be affected by muscle weakness, especially the knee extensor muscles, namely the quadriceps muscles. Therefore, it is important to discuss the problem of decreasing the range of motion of the knee joint in both extension and flexion after ACL reconstruction.

The following are some studies that are relevant to the problems that will be tested by researchers. Jae-Ho Yang, Seung-Pyo Eun, Dong-Ho Park, Hyo-Bum Kwak and Eunwook Chang (2019). Researching about *The Effects of Anterior Cruciate Ligament Reconstruction on Individual Quadriceps Muscle Thickness and Circulating Biomarkers. International Journal of Environmental Researchand Public Health. Published: 4 December*

2019. Next, Asghar Akbari, Fateme Ghiasi, Mohsen Mir & Mohammad Hosseinifar (2016) Researching about *The Effects of Balance Training on Static and Dynamic Postural Stability Indices After Acute ACL Reconstruction.* Global Journal of Health Science; Vol. 8, No. 4; 2016. And also, Sarah Noll, PT, DPT, OCS, ATC, J. Craig Garrison, PhD, PT, ATC, SCS, James Bothwell, MD and John E. Conway, MD (2015) Researching about *Knee Extension Range of Motion at 4 Weeks Is Related to Knee ExtensionLoss at 12 Weeks After Anterior Cruciate Ligament Reconstruction*. Investigation performed at Ben Hogan Sports Medicine, Fort Worth, Texas, USA 2015.

Based on the existing problems and relevant research, it encourages researchers to be interested in researching further about the effect of quadriceps muscle strength, knee range of motion (ROM) and motivation on static body balance in patients after ACL reconstruction at a special clinic for handling sports injuries, PhysioIN, Bekasi City, West Java.

METHOD

The research methods used in this research are quantitative approaches, survey methods with measurement techniques and tests, While the analysis technique uses a*path analysis*approach, which is a technique to analyze causal relationships that occur in multiple regressions if the free variable affects the variable depending not only directly but also indirectly (Maksum, 2018).

Target population study is all patient post-reconstruction ACL consisting of 30 patients. The sampling technique in this study is total sampling. The study sample was a post-reconstruction ACL patient who had conducted an exercise program at a special clinic handling sports injuries PhysioIN Bekasi. Static body balance instruments (Y) Using *the Stork Stand Test.* Quadriceps muscle strength instrument (X_1) Use the *quadriceps* muscle strength test with *the spignomanometer test. Range of motion* (ROM) knee ($X_{2)}$ Using a goniometer. Motivation (X3) uses a motivational test with a questionnaire, the questionnaire test is arranged according to the *likert scale.*

RESULTS AND DISCUSSIONS

Results

This research data consists of the results of static body balance (Y) as a variable *endogen*, Next, Quadriceps Muscle Strength (X_1), *Range of motion*

(ROM) knee (X_2) as a variable *eksogen* dan motivation (X_3) as a variable *intervening*.

Hypothesis Testing

Substructural Testing 1

Testing on structural model 1 to see the variable effect of *quadriceps* muscle strength (X_1) against *the range of motion of* the knee (X_2) in patients after anterior cruciate ligament reconstruction (ACL).

Table 6. Structural model path coefficient 1

Variabel	R^2	Koef Beta	*P-Value/2*
X_1X_2 (p_{21})	0,037	0,192	0,008

Based on table 6,it appears that R2 of 0.037 means that 3.7% variableity of the range of motion variable (X_2) can be explained by variable muscle strength *quadriceps* (X_1). So that eror (ε_1) = 1- R^2 = 1 – 0,037 = 0,063. Quadriceps muscle strength pathway coefficient (X_1) and *range of motion* (X_2) or (p_{21}) = 0,192 acquired value *Sig*. = 0,008/2= 0,004 < α = 0,05. From the results of testing structural model 1 is significant.

Substructural Testing 2

Testing on structural model 2 is variable muscle strength quadriceps (X_1), *range of* motion knees (X_2) and motivation (X_3) in patients after reconstruction *of the anterior cruciate ligament* (ACL).

Table 7. Structural Model Path Coefficient 2

Variabel	R2	Koef Beta	*P-Value/2*
X_1, X_3 (p_{31})	0,222	0,445	0,034
X_2, X_3 (p_{32})	0,156	0,262	0,031

Based on table 7, it appears that model 1 (R^2) 0.222 means that 22.2% and model 2 (R^2) 0.156 means that 15.6% of the variableity of the motivation variable (X_3) can be explained by variable muscle strength *quadriceps* (X_1) and *range of motion* (X_2). So that eror (ε_2) = 1- R^2 = 1 – 0,156 = 0,844. Path coefficient (X_1) towards (X_3) or (p_{31}) = 0,445 and (X_2) towards (X_3) or (p_{32}) = 0,262 acquired value *Sig.*= 0,034/2 =0,017 < α = 0,05 and *Sig.*= 0,031/2 = 0,0155 < α = 0,05.

Substructural Testing 3

Testing on structural model 3 is variable muscle strength quadriceps (X_1), *range of motion* (X_2), motivation (X_3) against static body balance (Y) in patients after reconstruction *of anterior cruciate ligament* (ACL).

Table 8. Structural significance test 3

Coefficients[a]

Model	Unstandardized Coefficients	Std. Error	Standardized Coefficients Beta		Sig.
(Constant)	6.820	34.467		198	000
X1	.151	.068	.360	.219	035
X2	-2.188	.661	-.502	3.311	003
X3	.156	.263	.396	.592	005

Path coefficient (X_1) towards (Y) or (p_{y1}) = 0,360; t_o = 2,219, p-value 0,035/2 = 0,0175 or Ho rejected. Thus, the muscle strength of the quadriceps

(X_1) Positive effect on static body balance (Y). Path coefficient (X_2) towards (Y) or (p_{y2}) = -0,502; t_o = -3,311, p-value 0,003/2 = 0,0015 or Ho rejected. Thus, *range of motion* (X_2) Negatively affect static body balance (Y), and path coefficients (X_3) towards (Y) or (p_{y3}) = 0,396 t_o = 2,592, p-value 0,005/2 = 0,0025 Or Ho was rejected. Thus, variable motivation (X_3) positive effect on the results of static body balance (Y).

Discussion

1. **The results showed there was a direct influence of quadriceps muscle strength on static body balance in patients after anterior *cruciate ligament reconstruction* (ACL)**

Based on the results of research conducted, that there is a direct influence of quadriceps muscle strength on static body balance in patients after anterior *cruciate ligament* reconstruction (ACL) with path coefficient results P_{y1} = 0,360 with *Sig* value = 0,005 < α = 0,0025. It turns out that the strength of the *quadriceps* muscle has a direct and significant effect on static body balance.

The effect of *quadriceps* muscle strength on static body balance 12,96%. While the rest 87,04% influenced by other factors. The results of this study are also strengthened by (Noviyanti, Santoso, & Widodo, 2014) With research entitled the relationship of muscle strength quadriceps femoris with the risk of falls in the elderly. The results of this study showed that the correlation test using the non parametrics spearman test, obtained results p = < 0,05 (p= 0,024) This means that the correlation between the muscle strength of quadriceps femoris and the risk of falls is meaningful, where there is a relationship between the two variables tested.

The conclusion of the study is that decreased muscle strength was identified as the most powerful risk factor associated with body balance in the elderly. Quadriceps femoris muscle is a muscle in the knee joint that serves as an active stabilization of the knee joint and also plays a role in the movement of the joint, namely the knee extension movement used in walking activities.

2. **The results showed there was a direct influence of the range of *motion of* the knee on static body balance in patients after anterior *cruciate ligament* reconstruction (ACL)**

Based on the results of research conducted, that there is a direct influence *on the range of motion* (ROM) knee to

the static body balance of the patient after reconstruction of the anterior *cruciate ligament* (ACL) with the result of the path coefficient P_{y2} = -0.502 with a Sig *value.* = 0.003 < α = 0.0015. It turns out that *the range of motion* (ROM) of the knee has a direct and significant effect on the balance of the static body.

The effect of the range *of motion* (ROM) of the knee on static body balance by 25.2%. The remaining 74.8% were affected by other factors. *A* good range of motion (ROM) knees is an important component in sustaining static body balance.

Conditions in which the inability of a joint to move optimally or a joint has very minimal motion has a significant impact on the balance of the static body. ROM management is caused by inattendity and to maintain the normality of ROM, joints and muscles must be moved to the maximum and performed regularly. (Winters;(Ulliya, Soempeno, & Kushartanti, 2010).

3. The results showed there was a direct influence of motivation on static body balance in patients after anterior *cruciate ligament* reconstruction (ACL)

Based on the results of research conducted, that there is a direct influence of motivation on static body balance in patients after anterior cruciate ligament reconstruction (ACL) with the results of the path coefficient Py3 = 0.396 with a value of Sig. = 0.005 < = 0.05. It turns out that motivation has a direct and significant positive effect on static body balance.

This means that if the patient has a high level of motivation, it will affect the level of recovery to regain a static body balance.

The effect of motivation on static body balance is 0.396 or 15.68%. While the remaining 84.32% are influenced by other factors. Motivation is part of the psychological aspect that affects a person's desire to recover. So that motivation is needed from within and from outside the patient so that the patient has a strong desire to carry out postoperative rehabilitation so that the static body balance can immediately return to normal.

4. The results showed that there was an indirect effect of quadriceps muscle strength through motivation on static body balance in patients after anterior cruciate ligament reconstruction (ACL)

Based on the analysis test results that the coefficient of the path of indirect influence given the intervening variable (p31.py3) is equal to (p31.py3 = 0.176). Based on previous findings, the direct effect of quadriceps muscle strength on static body balance was 0.360 or 12.96%, while the effect of quadriceps muscle strength through motivation on static body balance was 0.176 or 17.6%.

The total direct effect of quadriceps muscle strength on static body balance and the indirect effect given through motivation is 0.536 or 28.75%. This means that if these two variables are integrated, the effect obtained is very significant. It can be interpreted that the strength of the quadriceps muscle through motivation has a major influence on static body balance in patients after anterior cruciate ligament reconstruction (ACL).

The results of this study can be assumed that patients after reconstruction of the anterior cruciate ligament (ACL) who have good quadriceps muscle strength can certainly maintain a good static body balance supported by high levels of motivation and research conducted can be empirically correct. The rationale that has been presented in the conceptual framework can be tested for real.

5. The results showed that there was an indirect effect of knee range of motion (ROM) through motivation on static body balance in patients after anterior cruciate ligament (ACL) reconstruction

Based on the results of the analysis test that the coefficient value of indirect influence path given *intervening* variable ($p_{32}.p_{y3}$) It's as big as ($p_{32}.p_{y3}$ = 0,262). Based on previous findings, The direct influence of the range of motion (ROM) of the knee on static body balance is 0.502 or 25.2%, while the effect of the range of motion (ROM) of the knee through motivation on static body balance is 0.1038 or 10.38%.

The total direct effect of knee range of motion (ROM) on static body balance and the indirect effect given through motivation is 0.606 or 36.7%. This means that if these two variables are integrated, the effect obtained is very significant. It can be interpreted that the range of motion (ROM) of the knee through motivation has a major influence on static body balance in patients after anterior cruciate ligament (ACL) reconstruction.

6. The results showed that there was a simultaneous and significant effect of quadriceps muscle strength, knee range of motion (ROM) and motivation on body static balance in patients after anterior cruciate ligament (ACL) reconstruction

In the results of the path analysis calculation, it was found that there was a simultaneous effect of quadriceps muscle strength (X_1), *range of motion* (ROM) knee (X_2) and motivation (X_3) against static body balance (Y) Obtained R_{square} = 0,470 or by 47% so that H_o is rejected and Ha is accepted, where there is simultaneous and significant influence between the muscle strength *of quadriceps, range of motion* (ROM) knee and motivation to static body balance in patients post-reconstruction of the anterior *cruciate ligament* (ACL). This means that all *exogenous* variables have an influence on *endogenous* variables. Where the resulting effects are different but equally have an influence and contribution to the balance of the static body.

The effect obtained from these three *exogenous* variables is the strength of the quadriceps muscle (X_1), *range of motion* (ROM) knee (X_2) and motivation (X_3) to body static balance (Y) Showing a fairly large score that is 0,47 or 47%. The findings of this study statistically showed that static body balance was supported by three variables in this study, while the remaining 0.53 or 53% was caused by other factors.

CONCLUSION

Based on the results of hypothesis testing and discussion, conclusions were obtained from the exogenous variable, namely quadriceps muscle strength (X_1), *range of motion* (ROM) knee (X_2), and motivation (X_3), and variable endogenous static body balance (Y) It is as follows:

1. Quadriceps muscle strength has a direct and significant effect on static body balance in patients after reconstruction of the anterior cruciate ligament (ACL) by 6%.
2. Range of motion (ROM) of the knee has a direct and significant effect on patients after anterior cruciate ligament (ACL) reconstruction of 1.69%.
3. Motivation has a direct and significant effect on patients after anterior cruciate ligament (ACL) reconstruction by 15.8%.
4. Quadriceps muscle strength has a direct and significant effect on

motivation in patients after anterior cruciate ligament (ACL) reconstruction in West Jakarta U-12 archery athletes by 43.96%.

5. Range of motion (ROM) of the knee has a direct and significant effect on motivation in patients after anterior cruciate ligament (ACL) reconstruction of 44.76%.
6. The strength of the quadriceps muscle has an indirect effect on static body balance through motivation in patients after anterior cruciate ligament (ACL) reconstruction by 26.4%.
7. Range of motion (ROM) of the knee has an indirect effect on static body balance in patients after anterior cruciate ligament (ACL) reconstruction by 26.6%.

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