Essential Role of Serum Calcium for Muscle Strength in Football Athletes

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Abstract. Exercise increases the reabsorption of calcium from bones and inadequate intake of calcium resulting in hypocalcaemia. Hypocalcaemia is one of the factors causing the decline in leg muscle strength in athletes. The purpose of this study was to analysis the relationship of serum calcium levels and leg muscle strength in football athletes. The research subjects were 22 junior football athletes, male, age 12-17. The study design was an observational laboratory. Serum calcium levels were measured by using O-cresolphthalein complexone and leg muscle strength was measured by using a dynamometer leg. Data obtained were analysed by using Pearson correlation test and simple linear regression analysis (p<0.05). The results of Pearson correlation test (r) showed r=0.25; p=0.50, indicated that there is a low correlation between the serum calcium level and leg muscle strength, but not statistically significant. The results of simple linear regression analysis showed that the increase of serum calcium level by 2 mg/DL resulted in the increase of leg muscle strength about 13.07 kg. It can be concluded that serum calcium levels were positively associated with lower leg muscles strength, however, a decrease in serum calcium levels was not followed by a decrease in leg muscle strength in football athletes.

1. Introduction
Calcium is an essential mineral for the human body and has several important physiological roles for life [1] [2]. The adult human body contains approximately 1100g (27.5mol) of calcium and approximately 99% of the calcium is in bone [1]. Blood calcium levels are normally 9-10.2mg/dl (2.25-2.55mmol/L) [1][2][3]. Calcium is necessary for several physiological processes including regulating the formation and strength of bones and teeth, smooth and skeletal muscle contraction, neuromuscular
transmission, co-factor for many steps during blood coagulation, maintaining cell membrane permeability, regulate the hormones and growth factors, cardiac automaticity, nerve function, cell division and movement, and certain oxidative processes [1][2][3][4][5]. Intracellular calcium is involved as a second messenger in many intracellular responses to chemical and electrical stimuli and required by many enzymes for full activity [3][4][5].

Calcium balance in the body is regulated through a process of homeostasis involving three organs, namely: intestines, kidneys and bone issued three major hormones, namely: parathyroid hormone (PTH), calcitonin and calcitriol (1,25-dihydroxy-Vitamin D) [1][2][3][4][5]. Calcium absorption is related to calcium intake. If calcium intake is low, active transcellular calcium transport in the duodenum is increased and a larger proportion of calcium is absorbed by the active process compared with the passive paracellular process that occurs in the jejunum and ileum [3][4][5]. Calcium is a major component of bone [1][2][3][4][5]. The bone can act as a reservoir to allow serum calcium levels to be maintained, but excessive demineralization of bone as a result can lead to severe problems in athletes. Moderate exercise will respond in regulation the body's calcium homeostasis, support bone strength and density to achieve maximum peak bone mass [6][7][8][9]. Increased physical activity during exercise and the imbalance with calcium intake will lead to hypocalcemia [6][7][8][9].

Hypocalcemia affect the level of fatigue and muscle strength in athletes [5][6][7]. Hypocalcemia was defined as a total serum calcium level of less than 4.6 mg/dl [1]. Hypocalcemia cause disruption of bone formation and decrease the strength of the bone, the bones become brittle and fracture easily, and increases the risk of sports injury and early osteoporosis in athletes [4][5][6][7]. Hypocalcemia is expected to decrease the leg muscle strength in athletes of football that will ultimately result in decreased performance athletes during training and competition, but it still requires scientific evidence. Until now, we have not found studies on the relationship of calcium with leg muscle strength in athletes. Because on the basis of this reason, we conducted this research with the aim to analysis how the relationship between serum calcium levels with leg muscle strength in football junior athletes.

2. Methods
The study design was an observational laboratory. Subjects were 22 junior football athlete Aneuk Rencong Banda Aceh, male, age 12-17. Measurement of serum calcium levels using O-cresolphthalein complexone method by using a photometer 4010. Leg muscle strength was measured by using leg dynamometer. Data obtained were analyzed by using Pearson correlation test (p<0.05) and simple linear regression analysis (p<0.05).

3. Result
3.1. Overview of physical characteristics of subjects
The average age (years), weight (kg), height (cm), body mass index (BMI=kg/m2), systolic blood pressure (SBP=mmHg) and diastolic blood pressure (DBP=mmHg) of subjects are shown in Figure 1.

![Figure 1. Physical characteristics of subjects](image)
Figure 1 shows that the subject was classified as a teenager with the lowest age is 12 years, while the highest age was 17 years. The results of measurements of body mass index showed the weight average of subjects included in the category of normal (>18.50-25.00 kg/m²) and blood pressure of subject are normal limits (systolic 110-120 mmHg and 70-80 mmHg diastolic).

3.2. Serum Calcium Levels and Leg Muscle Strength of Junior Football Athletes

Figure 2 shows the number of athletes who have hypocalcemia as much as 18.18%. Normal calcium levels are 9.2 to 11.0 mg/dl.

![Figure 2. Percentage of hypocalcemia in football athletes](image)

The percentage of leg muscle strength as shown in Figure 3 indicated that the leg muscle strength of junior football athletes is a good category.

![Figure 3. Percentage of leg muscle strength junior football athlete](image)

The results showed that there are no junior football athlete who has a leg muscle strength in the perfect category. The average value of leg muscle strength is shown in Figure 4.

![Figure 4. The average of leg muscle strength in junior football athlete](image)
As shown in Figure 4, the value of leg muscle strength for football athletes is at the low category with the lowest value of 52 kg and the highest score was 126 kg. The relationship between serum calcium levels and leg muscle strength were analyzed by using Pearson correlation test \((r)\), \((p<0.05)\), shown in Table 2.

**Table 2.** Results of Pearson correlation test to determine the relationship of serum calcium levels and leg muscle strength in football athletes

| Subject          | \(R\)  | \(T\)  | \(p\)-value |
|------------------|--------|--------|-------------|
| Football Athletes| 0.25   | -0.68  | 0.50        |

Notes: *= There is a significant relationship at the level of error of 5% \((p <0.05)\); Correlation \((r)\): \(0.70\) = strong correlation; \(0.40\) to \(0.69\) = moderate correlation; \(0.20\) to \(0.39\); \(0.00\) = correlation is very low

The results of Pearson correlation test (Table 2) showed that there was a positive correlation \((r=0.25; \text{low correlation})\) between serum calcium levels and leg muscle strength in athletes, however the results were not statistically significant \((p=0.50)\). This indicated that a low serum calcium levels were not followed by decline in leg muscle strength in junior football athletes. Furthermore, the functional relationship between serum calcium and leg muscle strength were analyzed by using simple linear regression (Table 3). The general equation of simple linear regression, are \(Y = a + bX\). \(X = \text{serum calcium (independent variables)}\) and \(Y = \text{leg muscle strength (the dependent variable)}\).

**Table 3.** Results of simple linear regression to determine the functional relationship between serum calcium levels with a leg muscle strength in junior football athletes

| Subject          | regression equation                                      |
|------------------|----------------------------------------------------------|
| junior football athletes | \(Y = 212.75 + 13.07X\)                                |

Notes: \(X = \text{serum calcium}\); \(Y = \text{leg muscle strength}\)

The results of the calculations in Table 3 show that the decrease of calcium level by 2 mg/dl will lower the leg muscle strength by 13.07 kg.

**4. Discussion**

Calcium is a mineral that is necessary for our bodies to function. Calcium is especially important as a building block of bone tissue[7][11]. Calcium is a major component of bone. The skeleton is the major body storage site for calcium. A healthy adult contains \(1–1.3\ \text{kg}\) of calcium, and 99% of this is in the form of hydroxyapatite in the skeleton [11]. A healthy body always maintaining calcium in the normal range is called calcium homeostasis [1]. Negative calcium homeostasis occurs due to low calcium intake, impaired absorption of food and excessive calcium excretion. Negative calcium homeostasis resulting in increased loss of calcium from bone thus increasing the risk of sports injuries and early osteoporosis in athletes [1] [4] [5]. If the body lacks calcium, the body will take calcium from the bones reserves by increasing the bone calcium resorption. Increase bone calcium resorption resulting in increased calcium demineralization of bone that is characterized by hypocalcemia [6] [8].

The body's attempt to maintain normal blood calcium levels depend on the balance between income and expenditure calcium. When calcium intake is low, the body will stimulate the hormone calcitonin, thyroid hormones and vitamin D to maintain blood calcium is not decreasing [10][11][12]. The amount of calcium in the bones change with age. The calcium requirement in the teens/junior high athletes, this is due to increased levels of calcium absorption and calcium deposits reached 2 times more [4][5][18]. In the junior athletes, adequate calcium intake from food is needed to maximize the Peak Bone Mass (PBM) and maintain optimal body calcium homeostasis [12][13][14][15][16]. Low calcium intake will increase the risk of hypocalcemia in junior athlete [17][18][19]. This is consistent with the results of this study showed that the number of athletes who have hypocalcaemia junior football as much as 18.18%, but the causes of hypocalcaemia were not analysis.
The calcium requirement increases during exercise. Exercise need calcium to increase the strength of the muscles and joints [11][13][14]. Increased physical activity in Football resulted in the amount of calcium needed increases so increases calcium absorption from the gut [4][7][10][20][21]. If this condition occurs in the long term would occur hypocalcemia. Hypocalcemia is one of the causes of lower leg muscle strength in football athletes [7][9]. Football is a sport that predominantly use leg muscles. The results of this study showed that the average value of leg muscle strength junior football athlete is 90.23 kg (category enough). Hypocalcemia resulting in decreased muscle strength and increase the risk of sports injuries and early osteoporosis [13][14][15]. The results of this study indicate that the low correlation between the serum calcium level with leg muscle strength at a junior football athlete, but the results were not statistically significant. This result is due to the possibility of the small sample size. This research is preliminary and will be followed by experimental research.

Some research found that moderate intensity exercise a little increase plasma calcium slightly raise the bone mineral density (BMD) or bone density, bone strength [9][10][14][21] and average bone formation, increase serum levels of 1,25 (OH)2D3 level [19][20][21], and lowers parathyroid hormone (PTH) [10][21], as well as lower urinary calcium excretion [5][12]. Conversely, excessive exercise or strenuous exercise intensity resulted in increased serum PTH levels, decreased BMD [14], increased excretion of calcium from the urine, slightly lower serum calcium levels but no changes in the levels of 1,25-(OH)2 D3 serum [15][16][17].

5. Conclusion
The results of this study can be concluded that: serum calcium is positively related that there are no significant difference in leg muscle strength in athletes football, low levels of calcium is not associated with a lower leg muscle strength in athletes football, and decrease of serum calcium levels are not followed by a decrease in leg muscle strength in junior football athletes.

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