Association between Previous Experience of Strength Training under Appropriate Supervision and Knowledge of Squats among University Students Who Exercise Regularly*

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The aim of the present study was to investigate the effect of experience or inexperience with weight-training under appropriate supervision on the knowledge of squatting exercises among university students. A questionnaire-based survey was conducted among university students who exercise regularly (30 or more min per day, 2 or more days per week, and maintaining this for more than 1 year) to clarify the relationships between their experience of weight-training under appropriate supervision, knowledge of squatting exercises, and the frequency with which they perform squatting exercises ($n = 309$). More than half of the students who exercised regularly had never experienced weight-training under appropriate supervision. Approximately 50% of the participants performed squats periodically, even if they did not have any experience with weight-training under appropriate supervision. The participants who lacked experience with weight-training under supervision had made significantly fewer attempts to consciously train their gluteal and knee flexor muscles during squatting exercises than those who had experienced weight-training under supervision. In fact, approximately 50% of the former did not consciously train their gluteal muscles during squatting exercises at all. These results suggest that although the students performed squatting exercises periodically, those who had never experienced weight-training under supervision may not have properly understood the squatting method. Therefore, to enhance the benefits of training, people should be shown the correct method to perform training exercises and given appropriate supervision.

Keywords: Strength training, Exercise instructor, Hip extensor muscles, Knee extensor muscles

1. Introduction

Strength-training, which helps in the maintenance and development of muscle strength and mass, does

not only contribute to improved performance in competitive sports but also helps people maintain and improve their overall health. As such, it has attracted interests globally, Japan included. For

instance, although the Worldwide Survey of Fitness Trends*¹ acknowledged core training, boot camps, and yoga as fitness trends, strength-training has always been given the top priority (Thompson, 2011, 2012, 2013, 2014). The survey results also stated that the maintenance and enhancement of muscle function through weight-training concerns everyone, irrespective of age and sex (Thompson, 2013). Squatting exercises, for example, are the most typical (Ishii, 2009) and common (Chiu and Burkhardt, 2011) exercise within the set of dynamic resistance training (in this paper, squats refer to back squats or basic bodyweight squats). Although squats are usually associated with jumping or sprinting performances in athletes (McBride et al., 2009; Wisloff et al., 2004), they have been introduced by health and fitness organizations as a typical weight-training exercise (Ishii, 2009). In addition, they have recently been recommended for the prevention of “locomotive syndrome (Nakamura, 2008),” and as an exercise to strengthen the lower body muscles and improve balance (Nakamura, 2012).

Important muscles recruited during squatting exercises are the gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, intermediate vastus, vastus medialis, rectus femoris (Earle and Baechle, 2010), and erector spinae (Aruga, 2009). In short, squatting exercises train the hip as well as the knee extensors (Earle and Baechle, 2010; Aruga, 2009). It is also an exercise of multi-joint movements, recruiting several muscle groups. Therefore, it provides a higher variety and freedom of movement, compared to exercises that incorporate only single-joint movements. The activity of recruited muscle groups during squatting exercises varies according to the width of feet stance (McCaw and Melrose, 1999), angles of the knees and hips (Escamilla et al., 1998; Fry et al., 2003; Manabe et al., 2004), squatting depth (Caterisano et al., 2002), and weight load (Manabe et al., 2003). In addition, several reports suggest that squats are difficult to perform if the flexibility of one’s lower body (including the pelvic girdle) is less, or if one’s range of motion is restricted (Fukui, 2006; Miura and Oda, 2001; Ogasawara, 2013). For these reasons, there have been various discussions regarding the proper technique of performing squats; some researchers have pointed out that it is a difficult exercise to perform correctly, even among athletes (Chiu, 2009). In fact, a study that examined young people’s recogni-

tion of trained body parts while doing squats reported that most of them did not recognize the gluteal as a trained area (Oshita et al., 2014). This indicates the likelihood of squats being performed incorrectly, like a lower torque movement of the hip joints.

Strength-training performed wrongly not only leads to the loss of its beneficial effects but also increases the risk of injuries. Therefore, strength and conditioning organization advocates performing squats under appropriate supervision (National Strength & Conditioning Association, 1991). In fact, this should apply to all sports activities, in order to ensure that they are “safe, correct, and fun” (Japan Sports Association, 2014). However, this is not the case with many exercises. For example, a survey among athletic club faculties of junior high schools and high schools across the country reported that 40–45% of these faculties were not in charge of physical education and did not have experience in the activities they were responsible for (Japan Sports Association, 2014). Moreover, in a survey of a particular region, it was reported that 69% of the athletic club faculty did not possess teaching licenses for physical education or certified qualifications from the Japan Sports Association (Teraoka and Matsumoto, 2015). These reports suggest that most strength-training and sports activities are likely carried out without appropriate supervision.

Unfortunately, unlike competitive sports, there are no sporting regulations or rules for strength-training; instead, various exercising methods are featured in books, television programs, and so on. Therefore, an individual can strength-train even without prior supervision and knowledge of these exercises. However, if strength-training is improved with appropriate supervision, this could increase the appeal of a professional instructor. Furthermore, it may strengthen evidence of this importance as recommended by strength-training organizations. The aim of this study was to investigate the effect of experience or inexperience with weight-training under appropriate supervision on the frequency of performing squatting exercises (the most common (Chiu and Burkhardt, 2011) and typical (Ishii, 2009) exercise in strength-training) and the knowledge of squatting exercises among university students.

2. Method

2.1. Participants

Our participants comprised 494 men and women from national universities, private universities, and national colleges of technology (where a fourth-year college student is the equivalent of a first-year university student). A questionnaire-based survey was conducted from October to December 2014 using the collective survey method. Participants were verbally informed beforehand that the questionnaire answers would be anonymous and used only for research purposes. They were also informed that while obtained data would be published after being statistically processed such that individuals cannot be personally identified, some diagrams may be published as they are. The survey was conducted only if these terms were accepted. This study was approved by the ethics committee of Kyushu Kyoritsu University.

2.2. Participants for analysis

The results of the questionnaire excluded 171 participants who, according to the National Health and Nutrition Survey conducted by the Ministry of Health, Labor and Welfare (2014), did not exercise regularly, have never performed squats, or did not know about squats. It further excluded 14 participants whose answers were incomplete. This left 309 participants (264 men and 45 women) for the analysis. This study limited the participants of analysis to those who exercised regularly (30 minutes or more per day, 2 or more days a week, and maintaining this for more than 1 year), considering reports that regular exercise habits affect one's recognition of trained body parts (Oshita et al., 2014). Furthermore, we postulate that participants without regular exercise habits are less likely to have received supervised weight-training.

Among the participants, 22 did not participate in any sport, while the remaining 272 did. The breakdown according to specific sports is as follows (numbers in brackets indicates the number of participants): soccer (40), baseball or softball (37), basketball (34), swimming (30), track and field (28), Kendo (23), lifeguarding (14), rugby or American football (14), volleyball (9), futsal (9), gymnastics/acrobatics/dancing/cheerleading (9), handball

(6), tennis (5), badminton (5), snow sports such as skiing or snowboarding (4), under-water sports including diving or surfing (4), double Dutch (3), rowing (3), triathlon (2), combative sports (2), golf (1), mountaineering (1), hockey (1), cycling (1), lacrosse (1), and ultimate Frisbee (1).

2.3. Questionnaire survey

The questionnaire-based survey was conducted under five headings: participants' physical activity status, competitive records, experience with weight-training under appropriate supervision, frequency of performing squats, and perceived body parts trained by squats.

Question 1, relating to physical activity, was "Do you exercise more than twice a week (for at least 30 minutes at a time)?" with the three answer options, "No, I do not," "Yes, for less than a year," and "Yes, for more than a year."

Question 2, relating to competitive records, was "Please select the appropriate option in relation to your competitive records," with the four answer options, "National competition finalist or higher," "National competition participant," "Regional competition participant," and "Others (including no experience in competitive sports)."

Question 3, relating to the experience with weight-training under appropriate supervision, was "Have you weight-trained under appropriate supervision?" with two answer options: "Yes" and "No." Those who answered "No" were further asked whether "they exercised without any reference" or whether "they exercised while watching videos" and so on. Additionally, those who answered "Yes" were asked whether they received guidance from weight-trainers, sports experts, or individuals who were of neither these two professions (e.g., seniors, friends, etc.).

Since squatting exercises in this study are classified into sissy squats, front squats, and others, question 4 (relating to the frequency of performing squats) was presented along with a picture of a back squat from the manual of the National Strength & Conditioning Association (**Figure 1**) (Earle and Baechle, 2010). The question was "Have you performed a squat as shown in the picture?" with the following 6 answer options: "Almost everyday," "Several times a week," "Several times a month," "At least once," "Never," and "I do not know about

Q5 Have you performed a squat as shown in the picture?

Almost every day Several times a week Several times a month At least once Never I do not know about squats

Q6 Which body parts do you think are trained when performing a squat as shown in the picture? (Please select all parts in right figure)

Figure 1 Questionnaire about the perceived body parts trained by squats
A picture of a back squat (source: the manual of the National Strength & Conditioning Association (Earle and Baechle, 2010))

squats”.

Question 5, regarding the recognition of body parts trained by squats, was “Which body parts do you think are trained when performing a squat, as shown in the picture?” To answer, participants were shown a diagram depicting the anterior and posterior views of the body. Body parts such as the neck, chest, epigastrium, hypogastrium, shoulders, upper arms, forearms, hands, thighs, lower legs, feet, back, lumbar, and buttocks were marked off (**Figure 1**). Participants could select multiple options in their answers.

2.4. Data analysis

When aggregating the results of the questionnaire analysis, the percentages of answer options for each question were compared using the chi-square goodness of fit test. This was followed by multiple analyses using Ryan’s method.

Based on their answers, participants were categorized into those who have experienced weight-training under appropriate supervision (EXP-group) and those without experience (NOE-group). The latter also included those who were supervised by non-professionals. To examine the relationship between competitive records, frequency of performing squats and supervised weight-training, a chi-square test was

performed. For perceived body parts trained by squats, the percentage of participants who did or did not recognize training of different body parts was compared between the EXP- and NOE-group using the chi-square test. We also conducted Fisher's exact test for cases where the expected frequency was below 5.

Using statistical analysis software (J-STAT version 12.5 and js-STAR version 2.0.6), the established level of statistical significance is less than 5%. We further calculated the V values using Cramer's method, and established the effect size as small for V less than 0.1, large for V greater than 0.5, and moderate for other cases.

3. Results

The aggregated results of the questionnaire are shown in **Table 1**. Among the participants, 12 were national competition finalists or higher, 67 were national competition participants or higher, and 149 were regional competition participants. The remaining 81 did not fall into any of these categories ($P < 0.01$). With regards to their experience with supervised weight-training (question 3), 146 participants had experience with professional weight-trainers or sports experts, 110 did not, while 53 had experience with individuals who were non-experts ($P < 0.01$). These results indicate that even among university students who exercised regularly, a majority of them have never experienced supervised weight-training. As for the frequency of performing squats (question 4), 3 participants performed squats almost everyday, 85 several times a week, 51 several times a month,

and 170 at least once ($P < 0.01$). This indicates that approximately half of university students with regular exercise habits perform squats periodically (several times a month).

Figures 2 and 3 show the aggregated results of each question by categorizing the EXP-group and the NOE-group accordingly. Among the EXP-group, 6.9% were national competition finalists or higher, 22.6% were national competition participants or higher, 47.9% were regional competition participants, and 22.6% did not fit into these categories. In the NOE-group, the percentages were 1.2%, 20.9%, 48.5%, and 29.4%, respectively. With no significant difference being observed, the effect size was moderate ($V = 0.16$) (**Figure 2**). This suggests that there is no observable association between one's experience with supervised weight-training and one's competitive record.

With regards to the association between one's experience in supervised weight-training and frequency of performing squats (question 4), the EXP-group consisted of 1.4% who performed squats almost everyday, 31.5% several times a week, 17.8% several times a month, and 49.3% at least once; on the other hand, the NOE-group had 0.6%, 23.9%, 15.3%, and 60.1%, respectively. Again, no significant difference was observed here and the effect size was moderate ($V = 0.11$) (**Figure 3**). This indicates that prior supervised weight-training had no influence on the frequency of performing squats. In fact, approximately half of the participants performed squats periodically, even if they did not have any experience with weight-training under appropriate supervision.

Table 1 Aggregated results of the questionnaire

(Question 2) Competitive records	① National competition finalist or higher	② National competition participant or higher	③ Regional competition participant or higher	④ Other
$\chi^2 = 123.30, P < 0.01$ ① < ②, ① < ③, ① < ④, ② < ③, ③ > ④; $P < 0.01$	3.9% (n = 12)	21.7% (n = 67)	48.2% (n = 149)	26.2% (n = 81)
(Question 3) Experience with undergoing instruction for strength training	① None	② From experts	③ From non-experts	
$\chi^2 = 42.70, P < 0.01$ ① < ②; $P < 0.05$, ① > ③, ② > ③; $P < 0.01$	35.6% (n = 110)	47.2% (n = 146)	17.2% (n = 53)	
(Question 4) Frequency of performing squats	① Almost everyday	② Several times a week	③ Several times a month	④ At least once
$\chi^2 = 192.42, P < 0.01$ ① < ②, ① < ③, ① < ④, ② > ③, ② < ④, ③ < ④; $P < 0.01$	1.0% (n = 3)	27.5% (n = 85)	16.5% (n = 51)	55.0% (n = 170)

Figure 2 Competitive records (question 2) among the EXP- and NOE-group

EXP-group: Participants who have experience with weight-training under appropriate supervision

NOE-group: Participants who have no experience with weight-training under appropriate supervision and/or who have received supervision with non-professionals

Figure 3 Frequency of performing squats (question 4) among the EXP- and NOE-group

EXP-group: Participants who have experience with weight-training under appropriate supervision

NOE-group: Participants who have no experience with weight-training under appropriate supervision and/or who have received supervision with non-professionals

Figure 4 shows the aggregated results for the association between experience with supervised weight-training and recognition of trained body parts (question 5). In both groups, most participants (90%) perceived the anterior thighs as trained areas. The corresponding percentages for the other parts were 80–90% for the posterior thighs, 50–70% for the gluteal muscles, 40% for the lumbar and posterior lower legs, 30% for the anterior lower legs, 20–30% for the hypogastrum and back, 10% for the epigastrium and shoulders, 5–10% for the feet and arms,

2–7% for the posterior neck, and less than 5% each for the chest, forearms, hands and anterior neck. Among these, 92% of the EXP-group marked the posterior thighs, compared to 83% of the NOE-group; similarly, 69% of the EXP-group marked the gluteal region, compared to 56% of the NOE-group. Interestingly, only 2% of the EXP-group marked the posterior neck, compared to 7% of NOE-group. Significant differences were observed between the groups ($P < 0.05$), and the effect size was moderate ($V = 0.12$ – 0.14) in these parts. For other body parts,

Figure 4 The percentage of participants who did recognize training in each body parts during squats (question 5) among the EXP- and NOE-group

EXP-group: Participants who have experience with weight-training under appropriate supervision

NO-group: Participants who have no experience with weight-training under appropriate supervision and/or who have received supervision with non-professionals

A: Anterior

P: Posterior

*; $P < 0.05$

**; $P < 0.01$

Figure 5 Example of answers regarding perceived body parts trained during squats (question 5)

①Experience with appropriate supervision for weight-training

②Frequency of doing squats

difference between the groups was not statically significant, and the effect size was small ($V < 0.1$). These results suggest that although more than 80% of participants recognized that thighs are being trained, the recognition of the posterior thighs was higher among participants who had supervised weight-training; similarly, about 70% of partici-

pants who had supervised weight-training recognized the training of the gluteal region, compared to only half of participants without appropriate supervision. Interestingly, the posterior neck, although infrequently marked, was recognized by more participants in the NOE-group than the EXP-group. An example of these answers is shown in **Figure 5**.

4. Discussion

This study revealed that 1) even among university students who exercised regularly, more than half never received supervised weight-training; 2) the experience of appropriate supervision had no effect on the frequency of performing squats, and; 3) those without prior supervised training have less perception of the training of hip extensor muscles during squats.

Strength-training is important for everyone, irrespective of their age and sex. The presence of an appropriate supervisor is equally significant. In their annual prediction for top fitness trends, the Worldwide Survey of Fitness Trends*1 listed certified and experienced fitness professionals in third place in their 2014 and 2013 surveys (Thompson, 2013, 2014); in 2012 and 2011, these experts were placed first (Thompson, 2011, 2012). This shows that there is a worldwide demand not only for fitness instructors, but also for those with a high degree of knowledge and experience in this field. However, the results of the present study showed that even among university students who exercised regularly, more than half have never received appropriate supervision. Using squats as a representative strength-training exercise, this study found that the frequency of performing squats was not dependent on prior supervised training, and that approximately half of the participants performed squats periodically, regardless of their experience. Although performing squats with supervision is important as it enhances performance and prevents injuries (National Strength & Conditioning Association, 1991), our results showed that strength-training is often practiced in the absence of appropriate supervision.

With regards to the recognition of trained body parts, although many participants identified thighs (both anterior and posterior) and gluteal muscles, a significant difference between the EXP- and NOE-group was observed for the gluteal region and posterior thighs. When performing squats, it is recommended that the knees are positioned exactly above the feet (Aruga, 2009; Earle and Baechle, 2010), and that the shins are kept straight (Fry et al., 2003) while descending and ascending; in other words, the exercise is performed akin to “sitting on a chair (Chiu, 2009).” Performed this way, squats can build up the knee- and hip extensor muscles, and reduce the risk of injuring lower limb joints

(Manabe et al., 2004). This effectively strengthens the muscles of the lower body. For squats with 60–70% repetition maximum resistance, more than 40% maximum voluntary contraction activation can be seen in the rectus femoris, vastus lateralis, and intermediate vastus muscles during the descending and ascending phases (Escamilla et al., 1998; Manabe et al., 2004). Although the activity of the gluteus maximus and biceps femoris is almost the same compared to that of the rectus femoris and vastus lateralis during the ascending phase, the activity is lowered during the descending phase (Escamilla et al., 1998; Manabe et al., 2004). These results suggest that the perception of training the gluteal region and posterior thighs is lower than that of the anterior thighs, where there is greater activity during both the ascent and descent. However, squats is an exercise to train hip extensor and knee extensor muscles. Therefore, based on the principle of consciousness (Kouda, 1994), squats should be performed with a perception to train hip extensor muscles as well as knee extensor muscles. On the other hand, when performing squats, the same level of activity is observed in the erector spinae muscles as well as in the rectus femoris and vastus lateralis muscles (Manabe et al., 2004), in order to maintain the posture of the trunk. However, less than half the number of participants marked the lumbar area (which contains the erector spinae muscles) in their answers, irrespective of their experience with supervised training. This may have been secondary to less prioritization in maintaining posture when performing squats. It is therefore advisable to practice any form of exercise only after one has a clear understanding on how to consciously perform it.

There is also the possibility that squats are not performed correctly when there is less perceived training of the hip extensors (i.e., the posterior thighs and gluteal muscles). For instance, a squat is performed by keeping the upper body upright and the act of bringing the knee joints forward without flexing the hips causes greater torque on the knee joints compared to the hip joints (Fry et al., 2003). During this act, the activity of the rectus femoris muscle significantly increases while that of the femoral biceps significantly reduces (Manabe et al., 2004). In addition, limitations in squat movements may arise depending on the flexibility of one's lower body muscles, including the pelvic girdle (Fukui, 2006; Miura and Oda, 2001, Ogasawara, 2013). If a

person performs squats with a shallow angle motion, the activity of the gluteus maximus is reduced compared to that of the thigh muscles (vastus lateralis, vastus medialis and biceps femoris) (Caterisano et al., 2002). Since the present study only investigated the body parts trained by squats and did not examine the actual movements, these suggestions are mere conjectures. However, reports have stated that when squats are perceived to exercise only the femoral quadriceps, there is a tendency to perform greater knee joint torque squats (Ogasawara, 2013). Therefore, participants in the NOE-group might have performed higher number of knee joint torque squats, leading to lowered levels of perceived training of the gluteals and posterior thighs. In the case of greater knee joint torque squats, the load on the knee joints increases the more the knees are brought forward (Ishii, 2009). In order to prevent chronic knee problems, it is recommended to not position the knees beyond the front of the toes (Ishii, 2009). While a slight forward-position may train many lower limb muscles (Fry et al., 2003), excess is a common error (Aruga, 2009). The results of this study suggest the possibility that exercises may be performed wrongly due to differences in perceived trained body parts as a result of one's experience with supervised training. It also stresses the importance of appropriate supervision in preventing injuries during exercise.

As shown in the example in Figure 5, some participants perceived training in their arms, shoulders, and/or neck while doing squats. Although few participants marked the posterior neck, more NOE-group participants marked this area compared to the EXP-group. There is a possibility that the arms, shoulders, and neck were marked in the answers as a result of the depiction of a back squat (with a shaft being carried on the shoulders) in the questionnaire (Figure 1). Even among participants who exercised regularly, some answered the lower relation parts during actual movements of the squat; i.e., arms, shoulders, hand, and neck. Even among participants who experienced supervised training (and performed squats several times a week), some of them did not consciously train their gluteals; instead, they only perceived training in the upper arms and shoulders (Figure 5). Comparatively, only 30% of participants without regular exercise habits perceived training of the gluteal region when doing squats (Oshita et al., 2014). This suggests that appropriate supervision is

of even greater importance in strength-training beginners who do not regularly exercise. Furthermore, about 10% of the EXP-group did not know that the knee extensors are amongst the trained areas. As shown in Figure 5, the anterior thighs were not marked while the gluteals and posterior thighs were, implying that squats are perceived as greater hip extension exercises, like the “good-morning exercise (Contreras et al., 2013).” Since most exercises can be easily performed through observation, awareness of the importance of professional instructors may be reduced. Strength-training should be performed with the proper methods and understanding in order to maintain and promote muscle strength and mass, as well as improve the quality of life. The results of the present study showed evidence of the importance of strength-training under appropriate supervision.

Unfortunately, this study only examined the perception of trained body parts in squats; further studies are necessary to consider what movements are actually performed. In addition, we only focused on university students, limiting other population samples. As for experience with supervised training, the question of whether one was a professional or expert trainer was up to the participants' subjective judgment. The level of these supervisors' knowledge or expertise is not certain. The Japan Sports Association (2014) conducted a survey among the teachers in charge of sports club activities, to examine their level of awareness about the qualifications of a coach in the association. They reported that 61% of junior high school teachers and 48% of high school teachers were not aware of these qualifications, suggesting that the level of awareness regarding these credentials was low. On the other hand, although various organizations such as the Japan Health Promotion & Fitness Foundation, the Japan Association of Training Instructors and the National Strength & Conditioning Association (to name a few), provide accreditation for qualifications and degrees related to exercise training, it is unclear whether they are generally recognized. Therefore, this study was investigated by the judgment of the strength training and sports experts on the subjectivity of the participants. Moreover, it suggests that even among qualified instructors, their expertise may not be guaranteed by these qualification systems (Nagamatsu and Morino, 1999). Furthermore, individuals with no prior credentials may have practiced strength-training from knowledge gained

through their personal efforts. Further detailed studies need to be conducted in relation to qualifications and credentialing of supervisors, as well as on participants' own level of knowledge regarding weight-training.

5. Summary

The present study investigated whether prior experience of supervised weight-training is related to the frequency of performing squats and the knowledge of squatting exercises among university students. More than half of the participants who exercised regularly had never experienced weight-training under appropriate supervision. Approximately 50% performed squats periodically, even in the absence of supervised weight-training. We found that participants with no experience in weight-training under supervision made significantly fewer attempts to consciously train their gluteal and knee flexor muscles during squats, compared with those with experience. In fact, approximately 50% of the former did not consciously train their gluteal muscles during squats at all. These results suggest that although the students performed squatting exercises periodically, those without supervised weight-training may not have properly understood the exercise method. Therefore, to enhance the benefits of training, people should be shown the correct method of performing these exercises and given the appropriate supervision.

Note

*1 A questionnaire survey carried out by the American College of Sports Medicine on people around the world working in the fitness industry, regarding what fitness-related trend they thought would be prevalent in the following year. There were 3,403 respondents for the 2014 survey (Thompson, 2014).

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Main Works:

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