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쭈그려 앉기의 단계화와 표준화된 검사에 대한 연구

정형국
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Study on the Phases and Testing Standard of Standing to Squatting Position

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Purpose: This study examined the various patterns of standing to squatting activities, and reports the testing standard and phases for examining the standing to squatting position.

Methods: One thousand, normal college students (500 males, 500 females) volunteered for this study. The patterns are performed by naked eye analysis with two video cameras.

Results: The patterns from the standing to squatting position are as follows: 1. parallel with the heel on the pattern; 2. parallel with the heel off the pattern; 3. closed with the heel on the pattern; 4. closed with the heel on the pattern; 5. open with the heel on the pattern; and 6. open with the heel on the pattern.

Conclusion: The phases of the standing to squatting position are as follows: phase Ⅰ from standing to the anterior parts of the knees reaching the anterior limit of the BOS, phase Ⅱ from phase Ⅰ until the height of the hip and knee joints are the same, phase Ⅲ from phase Ⅱ until there was no full squatting and the heels broke contact with the floor and phase Ⅳ from phase Ⅲ full squatting on the heels in contact with the floor.

Key Words: Squatting position, Testing standard, Phases and patterns

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Ⅰ. Introduction

Squatting is very easy for healthy people, and has been a good area of research on human activity. However, it appears to be affected more by lifestyle, physical characteristics, age, gender, and culture environments than by gait. Unlike a gait study, squatting has received less attention. According to the pathological conditions, the extent and behavior of squatting can be significantly different. Carr & Shepherd (1996) reported that squatting will become a very important subject in a study of human activity. Because squatting is one of the daily activities and plays important role in sporting activities, its importance has increased gradually. Moreover, it has been highlighted as one of closed kinetic exercises (Escamilla et al, 2001).

Currently, squatting studies have focused on two areas. The first squatting study examined movement concepts. The second examined the position concept as pursued by Lee & Chung (1998). Since the merits of squat testing do not require a complicated explanation or spatial restrictions, most tools for testing the function of the lower extremity have a squat testing item

(Tegner & Lysholm, 1985; Marshall et al, 1977). Squat testing is quite valuable in examining the functions of the lower limb. In particular, squat testing for elderly and orthopedic patients is quite valuable clinically. However, the Lysholm Knee Scale, which is a tool for assessing the functions of the lower limb, has eight items with a total score of 100. On the other hand, the squat score comprises 5 points only, and does not present a standardized squatting position. According to Chung (2004), even if the squatting activity is simple, it will be very difficult for those with neurological and orthopedic problems. Therefore, squat testing can be used to evaluate the functions of the lower limb.

The aims of this study were to understand situations where various patterns can occur during standing to the squatting activity, and present the phases and testing standard of the standing to squatting position.

Ⅱ. Methods

1. Participants

One thousand, healthy participants (500 males and 500 females) volunteered for this study (Table 1). The subjects provided informed and written consent, experienced no knee pain, and had no orthopedic or neurological problems. They performed the standing to squatting position and the hand-toe test before participation. This experiment was carried out from March 23th, 2005 to September 7th, 2007.

Table 1. Participants characteristics

Gender	Male(n=500)	Female(n=500)	Total(n=1,000)
Age(yrs.)	25.24±6.44	21.02±3.56	23.56±4.46
Height(㎝)	173.76±13.21	162.23±4.32	168.02±10.98
Weight(㎏)	67.43±11.22	54.22±7.13	60.95±11.88

2. Experimental Procedures

Two cameras were used in this experiment. One was placed in the front and lateral side of the participants, respectively, but they were not synchronized. The distances between the participant and the front and lateral cameras were 4m and 2m, respectively. The start position of the participants was standing on their bare feet shoulder width apart. Because clothes can interfere with the free squatting activity, the participants were asked not to wear tight pants, and speed of the activity was not controlled during squatting.

Ⅲ. Results

In Table 2, the male participants showed a similar numerical value for the heel on and heel off patterns, but the numbers in the heel on pattern in females showed higher values than the numbers in the heel off patterns. Table 3 shows six patterns and Table 4 shows 3 heel off times. The 6 patterns and 3 heel off times were combined. Of the 15 standing to squatting position patterns produced, the patterns, parallel with the heel on and open with the heel on, were most common in females and males, respectively. Unlike females, males have no closed with the heel on pattern or closed with the heel off patterns. Most participants performed parallel with the heel on pattern regardless of gender.

Table 2. total heel conditions in standing to squatting position

Patterns	Total(n=1,000)	Male(n=500)	Female(n=500)
heel on	642	264	378
heel off	358	236	122

Table 3. combined conditions of knee and heel in standing to squatting position

Patterns	Total(n=1,000)	Male(n=500)	Female(n=500)
parallel with heel on	365	62	303
parallel with heel off	276	195	81
closed with heel on	30	0	30
closed with heel off	11	0	11
open with heel on	247	202	45
open with heel off	71	41	30

Table 4. Only heel conditions in standing to squatting position

Patterns	Total(n=276)	Male(n=195)	Female(n=81)
heel off at start	85(30.79%)	61(31.28%)	24(29.62%)
heel off during	99(35.86%)	69(35.38%)	30(37.03%)
heel off at end	92(33.33%)	65(33.33%)	27(33.33%)

The patterns from the standing to squatting position are as follows:

1. parallel with the heel on pattern: both knees move in parallel during squatting and the heels come in contact with the floor at the squatting end position.
2. parallel with the heel off pattern: both knees move in parallel during squatting and the heels do not come in contact with the floor at the end position.
3. closed with the heel on pattern: both knees come in contact with each other and the heels come in contact with the floor at the end position.
4. closed with the heel on pattern: both knees come in contact with each other and do not come in contact with the floor at the end position.
5. open with the heel on pattern: both knees are spread out and the heels come in contact with the floor at the end position.
6. open with the heel on pattern: both knees are spread out and the heels do not come in contact with the floor at the end position.

Ⅳ. Discussion

Classifying the phases of any activity, such as walking, is the key to an activity study. The gait cycle consists of two phases (stand and swing phase), and gait studies had been carried out using gait phases. Carr & Sphered (2000) divided the sitting on a chair to the standing position into two phases but there are no reports on the phases of the standing to squatting position.

Subdivision of the daily activity and studies of the activity patterns are essential for an activity study. Buxton (1938), Hanson & Jones (1970), and Dhesi & Firebaugh (1972) suggested the concept of 'hunker' and 'squat'. According to them, 'hunker' means that heels come in contact with the floor during squat sitting but 'squat' means that the heels do not come in contact with the floor. Kim (1995) suggested that hunker and squat be distinguished. However, many researchers have identified two terms, as with this study. According to Kim (1995), most squatting studies deal with the subject of hunker, and in hunker, the hip and knee joints move further backward, and the heights of the hip joints are higher than in the squat. In addition, the COG in the squatting is positioned more forward than in the standing position but the COG in hunker is positioned more backward than in the standing position.

The results from the Chung study (2006) on the COG position and hip joint height were similar to the Kim study (1995). However, the distances between the hip and knee joint were higher in hunker than in squat. The height at the knee joint from the floor in hunker was higher than that in squat. Because this study observed free squatting without limitations, it was found that various squatting patterns occurred during squatting. The physical characteristics and age of the participants were considered because this study focused on the phases and testing standard of the standing to squatting position.

Dolenko (1974) reported that the flexibility of the spinal column, shoulder and ankle joint is important. Chung (2004) stated that no full squatting position occurs in those with neurological and musculoskeletal problems. The most important problem is joint hypomobility. As stated by many researchers, the knee joint is the worst problem for the standing to squatting position, and tissues around the hip joint also making a significant contribution (Hall & Brody, 1999). Levangie & Norkin (2005) stated that the joint forces on the patellofemoral joint change with the knee flexion angle, i.e., the strength of the quadriceps muscle and the tensile force of the patellar ligament increase with increasing knee flexion. In deep squatting, Dahlkvist et al (1982) compared the muscle strength (quadriceps, ham-

string, gastrocnemius) of the lower extremity with the joint force (patellofemoral joint and tibiofibular joint). Levangie & Norkin (2005) reported that muscle strength and joint force vary according to the position of the participants. However, unlike Dahlkvist et al, McCaw & Melrose (1999) suggested that the squatting to standing position requires more strength than the standing to squatting position. Accordingly, the knee flexion angle in the squatting positions was classified into a partial squat and deep squat. A deep squat means a squatting position with $>90^{\circ}$ knee flexion (Neumann, 2002). All the participants in this study were normal, and all accomplished the deep squat position.

As suggested by Escamilla RF et al (1998) and Wilk KE et al (1996), activated muscles vary with the knee flexion angle during the squat activity. This means that a muscle injury can cause changes in the squatting patterns. Escamilla et al (2001) examined the effects of distance between both feet. The gastrocnemius strength increased with increasing distance between feet. However, McCaw & Melrose (1999) reported no significant difference for the effects of the distance between feet.

Because squatting is a good tool for examining the function of the lower extremity, the testing standard of standing to squatting position is an essential item in a clinical assessment. Bolga & Keskula (1997) did not find pathological causes through squat testing. Therefore, it is a necessary item in clinical terms because it is very easy, quick, and requires no expert skill.

V. Conclusion

We observed the various patterns of standing to squatting activities, and suggest the testing standard for examining the standing to squatting position: in bare feet, the distance between both feet is shoulder width, both big toes are in the front and parallel, both knees move in parallel during squatting, and the heels come in contact with the floor. Because the phases of activities are core in motion analysis, we also suggest the phases of squatting: phase I from standing to the anterior parts of the knees reaching the anterior limit of the BOS, phase Ⅱ from phase I until the height of the hip and knee joints are the same, phase Ⅲ from phase Ⅱ until there was no full squatting and the heels broke contact with the floor and phase Ⅳ from phase Ⅲ full squatting on the heels in contact with the floor.

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