The Relationships between Low Back Pain/Knee Pain and Muscle Volumes of Extremities and Trunk

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Low back pain (LBP) and knee pain are among the most common orthopedic complaints. The factors associated with these pains are various, and their interactions are complicated; therefore, no consensus regarding causes and aggravation factors has emerged. Because LBP and knee pain deteriorate the QOL and ADL for elderly people, we examined the relationships between the experiences of LBP and knee pain and the muscle volumes of the trunk and extremities of 156 people aged 60 years and older participating in an exercise program. We used logistic regression analyses adjusted for age and gender. The decrease of latissimus dorsi muscle thickness was significantly associated with LBP ($P=0.048$), and the decrease of anterior femoral muscle volume was significantly associated with knee pain ($P=0.025$). The complication rate between LBP and knee pain was significant ($P=0.003$). Because our study is a cross-sectional study, there are no certainties about cause-and-effect relationships. However, our results suggest that back muscle exercises for people with LBP and training for strengthening the quadriceps femoris muscle for people with knee pain may be effective in reducing the frequency and intensity of the pain.

Keywords: low back pain, knee pain, back muscles, quadriceps femoris

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1. Introduction

Low back pain (LBP) and knee pain are the most common complaints of orthopedic patients. Various causes for LBP have been reported, for example lumbar intervertebral disc degeneration, spondylosis deformans [Luoma, et al. (2000)], spondylolisthesis, compression fracture [Shirakihara, et al. (2001)], abdominal and back muscular weakness [Van Tulder, et al. (2002)], physical loading to lumbar spine [Bahr, et al. (2004)], arteriosclerosis of the abdominal and lumbosacral arteries [Kauppila, et al. (2004)] and even psychological factors [Takeyachi, et al. (2003)]. However, there is no consensus on many of these factors because of the complex interactions among factors. In regard to knee pain, aging, female, obesity and knee injuries are unanimously considered as aggravating factors for gonarthrosis in previous reports, in contrast to factors such as osteoporosis, race, smoking, knee-periarticular muscle strength

and exercise [Fukuda and Nakamura (2002); Burger, et al. (1996); Cheng, et al. (2000)]. It is difficult to assess LBP and knee pain because they are subjective sensations. In spite of this difficulty, some studies reported that LBP [Shirakihara, et al. (2001); Fukuhara, et al. (2003)] and knee pain [Morishita (1997)] are associated with quality of life (QOL) and activities of daily living (ADL) of the elderly; therefore, we suspect these symptoms as important influential factors on the ADL and QOL of the elderly.

Furthermore, the torque and staying power of back muscles have also been reported to be reduced in patients with LBP [Roy, et al. (1989); Latimer, et al. (1999)]. Muto, et al. (1997) described that knee-extensor muscle strength was significantly weaker in a gonarthrosis group, and a prospective study showed that a group experiencing the onset of gonarthrosis tended to have weaker knee-extensor muscle strength at the baseline compared with a

non-gonarthrosis group [Slemenda, et al. (1998)]. These findings suggest LBP and knee pain are associated with muscle strength and volume of the lower extremities and trunk; therefore, training for improvement of LBP and strengthening of the quadriceps femoris muscle are promoted. The purpose of this study is to clarify the relationships between the experiences of LBP and knee pain and muscle volume of the extremities and trunk by investigating elderly subjects aged 60 years and older.

2. Method

2.1. Subjects

The subjects consisted of 156 elderly over 60 years old who were publicly recruited at three municipalities in 2002 to participate in an exercise program with the purpose of improving and promoting living function. There were 63 males and 93 females ranging in age from 60 to 82 yrs with a mean age of 69.0 yrs. All participants received written information about the study procedures and provided written informed-consent before participation in this program.

This study was approved by the Human Subjects Institutional Review Board of the Institute of Health and Sport Sciences, University of Tsukuba (Notification Number 29).

2.2. Questionnaire

A self-administered questionnaire concerning the experiences of LBP and knee pain was given to the participants to be completed. The questions were as follows: 1) Have you experienced LBP which continued more than one day during the last four weeks? 2) Have you experienced knee pain during the last four weeks?

2.3. Muscle thickness, normalized muscle volume, and muscle transectional area (muscle volumes = MVs)

Using a B-mode ultrasonic device (SSD-500, Aloka AG, Japan), we measured the muscle thickness of the abdominal rectus muscle at the right side of umbilicus and that at the inferior angle level of the right scapula, mainly the latissimus dorsi muscle, and the muscle thicknesses were used for analysis. Similarly, we measured the thicknesses of the

anterior and posterior muscles of the humerus, the anterior of the forearm, the anterior and posterior of the femur and the anterior and posterior of the crus. We estimated the muscle volumes by applying the measured muscle thicknesses to multiple regression equations [Miyatani et al. (2000)], then divided the volumes by the body weight, obtaining a normalized measure of muscle volume. The transectional areas of the bilateral psoas major muscles were measured by Magnetic Resonance axial image of the L4/5 intervertebral disc level and the mean of the left and right side areas for each subjects was used for analysis.

2.4. Statistical Analysis

We analyzed the relationships between LBP during the previous month and age, gender, and MVs, and between knee pain during the previous month and the same factors using t-tests and χ^2 -tests. Because age- and gender-related differences in MVs were suggested, MVs were adjusted by age and gender in logistic regression models, and odds ratios (ORs) and 95% confidence intervals were calculated. In the present study, we categorized age into two groups, ≤ 69 yrs versus ≥ 70 yrs for analysis. Calculated ORs were values per unit increase of muscle thickness (mm), normalized muscle volume (cm^3/kg) and muscle transectional area (cm^2). The relationship between LBP and knee pain during the previous month was analyzed using a χ^2 -test. The level of statistical significance was set at $P < 0.05$ and all statistical analyses were carried out using the computer software JMP version 5.1 (SAS Institute Inc., Cary, NC, USA).

3. Result

3.1. The relationship between LBP during the previous month and MVs (Table 1)

Twenty four of the 156 subjects (15.4%) had LBP during the previous month. The mean age of the group with LBP was 69.3 yrs and that for the group without LBP was 69.8 yrs. The difference was not statistically significant. Among our subjects there was no significant difference between the number of males experiencing LBP (15.8%) and the number of females (15.1%). As determined by univariate

Table 1 Logistic regression analysis for low back pain during the previous month by muscle volume

Variables	Crude		Adjusted †	
	OR	95%CI	OR	95%CI
Back muscle thickness (mm)	0.88*	0.78-0.98	0.88*	0.78-0.99
Abdominal muscle thickness (mm)	0.90	0.74-1.08	0.87	0.65-1.15
Psoas major muscle area (cm ²)	0.89	0.70-1.12	0.81	0.52-1.24
Anterior muscle volume of the humerus (cm ³ /kg)	1.07	0.61-1.88	1.82	0.65-5.31
Posterior muscle volume of the humerus (cm ³ /kg)	0.98	0.51-1.85	1.24	0.45-3.37
Anterior muscle volume of the forearm (cm ³ /kg)	0.84	0.56-1.23	0.37	0.14-1.06
Anterior muscle volume of the femur (cm ³ /kg)	1.08	0.93-1.26	1.25	0.94-1.68
Posterior muscle volume of the femur (cm ³ /kg)	1.08	0.86-1.34	0.97	0.75-1.26
Anterior muscle volume of the crus (cm ³ /kg)	0.99	0.57-1.61	0.98	0.45-1.97
Posterior muscle volume of the crus (cm ³ /kg)	1.00	0.78-1.28	0.93	0.66-1.31

OR: odds ratio; CI: confidence interval

ORs per one unit change of muscle volume were calculated.

† Each of the variables was adjusted by age and gender.

* $P < 0.05$ **Table 2** Logistic regression analysis for knee pain during the previous month by muscle volume

Variables	Crude		Adjusted †	
	OR	95%CI	OR	95%CI
Back muscle thickness (mm)	1.05	0.88-1.03	0.96	0.87-1.05
Abdominal muscle thickness (mm)	0.94	0.81-1.08	1.15	0.93-1.44
Psoas major muscle area (cm ²)	0.88	0.73-1.05	1.12	0.83-1.50
Anterior muscle volume of the humerus (cm ³ /kg)	0.59*	0.35-0.94	1.02	0.44-2.34
Posterior muscle volume of the humerus (cm ³ /kg)	0.63	0.36-1.06	1.23	0.58-2.63
Anterior muscle volume of the forearm (cm ³ /kg)	0.59*	0.42-0.85	0.52	0.26-1.11
Anterior muscle volume of the femur (cm ³ /kg)	0.86*	0.76-0.97	0.78*	0.62-0.96
Posterior muscle volume of the femur (cm ³ /kg)	0.91	0.76-1.08	1.01	0.82-1.26
Anterior muscle volume of the crus (cm ³ /kg)	0.90	0.58-1.36	0.82	0.45-1.41
Posterior muscle volume the of crus (cm ³ /kg)	0.99	0.81-1.20	1.25	0.95-1.68

OR: odds ratio; CI: confidence interval

ORs per one unit change of muscle volume were calculated.

† Each of the variables was adjusted by age and gender.

* $P < 0.05$

analyses using t-tests, back muscle thickness was significantly thinner in the group with LBP ($P = 0.025$) than the group without. Furthermore, in the logistic regression model adjusted for age and gender, only a decrease of back muscle thickness was significantly associated with LBP during the previous month (OR = 0.88, $P = 0.048$).

3.2. The relationship between knee pain during the previous month and MVs (Table 2)

Forty four of the 156 subjects (28.2%) experienced knee pain during the previous month. The mean age of the group with knee pain was 69.7 yrs while that of the group without knee pain was 69.8 yrs—no significant difference in age was observed between the two groups. The proportion of females with knee

pain was significantly higher than that of males—34.4% in females, 19.1% in males ($P = 0.034$). By univariate analyses the group with knee pain had significantly smaller anterior femur ($P = 0.015$), anterior humeral ($P = 0.033$) and anterior forearm ($P = 0.005$) normalized muscle volumes than the group without knee pain. Adjusting for age and gender in the logistic regression model as we did for LBP, a decrease of anterior femoral muscle volume per body weight (normalized muscle volume) was only significantly associated with knee pain during the previous month ($OR = 0.78$, $P = 0.025$).

The complication rates of LBP and knee pain were significantly high ($P = 0.003$) with 54.2% in the LBP group having of knee pain and 29.6% in the knee pain group having LBP.

4. Discussion

Because LBP and knee pain are symptoms which deteriorate ADL and QOL for the elderly, it is important to clarify the causes and associated factors. The deteriorations are also related to muscle volume and muscle strength. Thus, we focused on the relationships between LBP and MVs (muscle volumes) and between knee pain and MVs in the present investigation. Most previous reports on relationships between LBP or knee pain (gonarthrosis) and muscle strength or muscle volume dealt with a single muscle group, such as back muscles and the quadriceps femoris muscle. However, age- and gender-related differences are in reality observed in muscle volume and muscle strength, and individual muscle activities of extensors and flexors are balanced as antagonistic muscles; therefore, we adjusted for age and gender by multivariate analysis and examined the relationships between LBP and MVs of the extremities and trunk and between knee pain and MVs of extremities and trunk. As a result, the decrease of back muscle thickness which mainly reflects the thickness of the latissimus dorsi muscle, was significantly associated with LBP, and the decrease of anterior femoral muscle volume was significantly associated with knee pain. These results suggest that increases of muscle volume may ease pain, and that exercises to strengthen abdominal and back muscles, which are currently conducted on patients with LBP, and training to strengthen the quadriceps femoris muscle for gonarthrosis patients may be effective. However,

we could not identify the cause and effect because our study was a cross-sectional study; therefore, our results also indicate that these pains may prevent the participants from exercising enough and obtaining the health effects of training. Accordingly, in planning and executing exercise programs it may be useful to prescribe exercises which strengthen effective muscles to improve LBP and knee pain and permit continuous training without increasing pain. In future research, we need to clarify the relationships between changes of symptoms and muscle volumes through prospective longitudinal surveys.

When the subjects had LBP or knee pain, they significantly showed complication of the other symptom. From this finding, we think that it is important not to instruct only local training for the pain but to prescribe systemically balanced training.

5. Conclusion

In the subjects aged 60 years and older, the decrease of back muscle thickness was significantly associated with LBP and the decrease of anterior femoral muscle volume was significantly associated with knee pain. Our study suggests that strengthening back muscles and the quadriceps femoris muscle may be effective for LBP and knee pain.

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References

- Bahr, R., Andersen, S. O., Loken, S., Fossan, B., Hansen, T. & Holme, I. (2004). Low back pain among endurance athletes with and without specific back loading :a cross-sectional survey of cross-country skiers, rowers, orienteerers, and nonathletic controls. *Spine*, 29(4): 449-454.
- Burger, H., van Daele, P. L., Odding, E., Valkenburg, H. A., Hofman, A., Grobbee, D. E., Schutte, H. E., Birkenhager, J. C. & Pols, H. A. (1996). Association of radiographically evident osteoarthritis with higher bone mineral density and increased bone loss with age. The Rotterdam Study. *Arthritis and rheumatism*, 39(1): 81-86.
- Cheng, Y., Macera, C. A., Davis, D. R., Ainsworth, B. E., Troped, P. J. & Blair, S. N. (2000). Physical activity and self-reported, physician-diagnosed osteoarthritis: is physical activity a risk factor? *Journal of Clinical Epidemiology*, 53(3): 315-322.
- Fukuda, A. & Nakamura, K. (2002). Epidemiology of osteoarthritis of the knee. *Orthopedic Surgery (Separate volume)*, 42: 2-6. (in Japanese)

- Fukuhara, S, Suzukamo, Y., Takahashi, N., Konno, S. & Kikuchi, S. (2003). Supervision of Japanese Orthopaedic Association Science Project Committee. RDQ (Roland-Morris Disability Questionnaire) Japanese JOS edition manual. Tokyo: Japan Research Center. (in Japanese)
- Kauppila, L. I., Mikkonen, R., Mankinen, P., Peltto-Vasenius, K. & Maenpaa, I (2004). MR aortography and serum cholesterol levels in patients with long-term nonspecific lower back pain. *Spine*, 29(19): 2147-2152.
- Latimer, J., Maher, C. G., Refshauge, K. & Colaco, I. (1999). The reliability and validity of the Biering-Sorensen test in asymptomatic subjects and subjects reporting current or previous nonspecific low back pain. *Spine*, 24(20): 2085-2089.
- Luoma, K., Riihimaki, H., Luukkonen, R., Raininko, R., Viikari-Juntura, E. & Lamminen, A. (2000). Low back pain in relation to lumbar disc degeneration. *Spine*, 25(4): 487-492.
- Miyatani, M., Azuma, K., Kuno, S., Kanehisa, H. & Fukunaga, T. (2000). The difference due to age of limb muscle volumes. The method for improvement of older person's living function: local system and concrete guideline (pp.304-309). Tokyo: NAP Limited. (in Japanese)
- Morishita, T. (1997). The prevalence and risk factors of knee osteoarthritis and the effect on activities of daily living in the elderly: Epidemiological study in Okayama, Japan. *The Central Japan Journal of Orthopaedic Surgery & Traumatology*, 40: 11-19. (in Japanese)
- Muto, Y. Ohta-Fukushima, M., Koda, M., Kamioka, H., Takasugi, S. & Yasuda, K. (1997). The epidemiological study on the relationship between the osteoarthritis of the knee and physique and/or physical fitness. *Orthopedic Surgery*, 48(3): 365-370. (in Japanese)
- Roy, S. H., De Luca, C. J. & Casavant, D. A. (1989). Lumbar muscle fatigue and chronic lower back pain. *Spine*, 14(9): 992-1001.
- Shirakihara, N., Iwaya, T., Tobimatsu, Y., Oi, N., Yoshida, K., Urushiyama, Y. & Kondo, T. (2001). Quality of life and level of social activities affected by backache in the elderly. *The Journal of Japanese Society of Lumbar Spine Disorders*, 7(1): 65-72. (in Japanese)
- Slemenda, C., Heilman, D. K., Brandt, K. D., Katz, B. P., Mazzuca, S. A., Braunstein, E. M. & Byrd, D. (1998). Reduced quadriceps strength relative to body weight: a risk factor for knee osteoarthritis in women? *Arthritis and rheumatism*, 41(11): 1951-1959.
- Takeyachi, Y., Konno, S., Otani, K., Yamauchi, K., Takahashi, I., Suzukamo, Y. & Kikuchi, S. (2003). Correlation of low back pain with functional status, general health perception, social participation, subjective happiness, and patient satisfaction. *Spine*, 28(13): 1461-1466.
- Van Tulder, M., Koes, B. & Bombardier, C. (2002). Low back pain. *Best Practice & Research Clinical Rheumatology*, 16(5): 761-775.

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