Is perceived fear of being thrown related to changes in breakfall kinematics in novice judokas? : A preliminary study

Sentaro Koshida[1, 2)], Takanori Ishii[2, 3)], Tadamitsu Matsuda[4)], Toshihiko Yamada[3)], Yusuke Kanamaru[3)], Toshihiko Hashimoto[5)]

Department of Judotherapy and Sports Medicine, Faculty of Health Sciences, Ryotokuji University[1)]
Wellness Training Center, Ryotokuji University[2)]
Center for Liberal Arts Education, Ryotokuji University[3)]
Department of Physical Therapy, Faculty of Health Sciences, Uekusa-gakuen University[4)]
Center for Medical Education, Faculty of Health Sciences, Ryotokuji University[5)]

Abstract

Perceived fear of being thrown could be detrimental in breakfall kinematics and may even increase the risk of judo-related head injuries. The aim of this study was to investigate the association between perceived fear during the breakfall movement and its kinematics in novice judokas. Eight experienced and 10 novice judokas volunteered to participate. The novice participants were assigned to “fear” or “no-fear” groups using a 5-rank Likert scale. The breakfall motion data was collected at 500 Hz using three-dimensional motion analysis. Neck, trunk, right/left hip, and right/left knee joint angles in the sagittal plane and peak neck extension momentum were calculated, as described previously. A Kruskal–Wallis test with pairwise comparison was performed for group comparison ($P < 0.05$). We did not find significant differences in all but left knee angles between the two groups of novice judokas, while there were significant differences in most of the selected kinematic parameters among novice judokas and the experienced judokas. There was also no significant difference in the peak neck extension momentum between the groups of novice judokas. This study indicates that a perceived fear of the breakfall movement may not be greatly associated with the breakfall kinematics or possible risk of injury in novice judokas.

Keywords: martial arts, head injury, motion analysis, fear of injury

大外刈への恐怖感の有無は柔道初心者における受け身動作のキネマティクスと関連するか？：予備的研究

越田専太郎[1,2)]，石井孝法[2,3)]，松田雅弘[4)]，山田利彦[3)]，金丸雄介[3)]，橋本俊彦[5)]

了徳寺大学・健康科学部整復医療･トレーナー学科[1)]
了徳寺大学・ウェルネス･トレーニングセンター[2)]
了徳寺大学・教養部[3)]
植草学園大学　健康科学部理学療法学科[4)]
了徳寺大学　健康科学部医学教育センター[5)]

要旨

大外刈に対する恐怖感は適切な受け身動作の習得を妨げ，頭部外傷発生のリスクを高める可能性がある．本研究の目的は，柔道初心者における大外刈への恐怖感の有無と受身動作のキネマティクスとの関連を明らかにすることであった．10人の男子大学生柔道初心者および8人の柔道熟練者が本測定に参加した．大外刈に対する受け身動作を3次元動作解析装置により測定し,頸部，体幹，股関節，膝関節の矢状面角度変化および頸部伸展運動量を算出した．また，大外刈への恐怖感を5段階のリッカート尺度で回答させ，初心者の対象を「恐怖感有り」群,「恐怖感無し」群，に群分けした．Kruskal–WallisテストおよびSteel-Dwass法による対比較により各測定変数を3群間で比較した（$P < 0.05$）．初心者群間では左膝角度を除き，受け身動作時の関節角度の有意な違いは認められなかった． また，最大頸部伸展運動量についても初心者群間において恐怖感の有無による差は認められなかった．本研究の結果，柔道初心者において大外刈に対する恐怖感と受け身動作のキネマティクスとの関連は認められなかった．

キーワード: 武道, 頭部外傷, 動作分析, 外傷に対する恐怖感

INTRODUCTION

Previous studies have indicated that severe judo-related head injuries, such as acute subdural hematoma, predominantly occur among young and inexperienced practitioners, who account for approximately 90% of all severe cases.[1-3] The majority of judo-related head injuries results from being thrown backward with the osoto-gari technique.[1-3] Judo experts and medical professionals have agreed that avoiding direct head contact with the mat is crucial during breakfalls against osoto-gari to reduce the risk of head injuries, especially for young and inexperienced practitioners.

The osoto-gari technique involves the thrower pushing an opponent with his/her hands and sweeping out the supporting leg,[4-5] with the opponent expected to fall backward.[4] Previous evidence suggests that the breakfall for osoto-gari may be more physically and mentally demanding than breakfalls for other techniques.[6-8] Koshida et al. (2015)[9] demonstrated in a preliminary study that young judokas aged between 14 and 16 who already had years of judo experience exhibited different breakfall kinematics for osoto-gari to experienced adult judokas, suggesting that it is difficult for young judokas, even with experience, to master the proper breakfall skill needed for osoto-gari.

The difficulty of the breakfall and the perceived risk of injury may lead to a judoka perceiving fear and/or anxiety about being injured, which may be detrimental to learning the breakfall skill. Previous evidence has clearly shown that perceived fear and/or anxiety significantly changes postural control strategy[10-11] and gait pattern.[12] Such psychological conditions can result in changes even in more complicated tasks, such as athletic movements.[13] However, the association between perceived fear of being thrown and breakfall kinematics has not been adequately studied. The aim of this preliminary study was therefore to investigate this association in novice judokas. We hypothesized that novice judokas who feared taking the breakfall would exhibit different breakfall kinematics and head injury risk parameter compared to the experienced judokas and the novice judokas who did not have fear of being injured.

METHODS

Participants

Eight experienced male judokas and 10 novice male judokas volunteered to participate in the study. At the time of enrollment, each experienced judoka had at least 7 years of competitive judo experience, whereas the novice judokas had not previously participated in judo competitions, but had attended a minimum of 10 sessions of a judo course offered by our institution. The median (range) age, height, weight, and judo experience of the experienced judokas were as follows: 20 (19–21) years; 1.67 (1.59–1.84) m; 67.8 (58.9–93.2) kg; and 11.1 ± 4.0 years, respectively. The median (range) age, height, and weight of the novice judokas were 21 (20–22) years; 1.68 (1.63–1.81) m; and 71.8 (62.4–82.2) kg, respectively. We obtained written informed consent from all the judokas prior to participation. The study protocol was approved by the Ethics Committee of the Faculty of Health Sciences, Ryotokuji University.

Testing protocol and data acquisition

All testing was performed in the motion analysis laboratory at Ryotokuji University, Japan. Three-dimensional marker trajectory data (collected at 500 Hz) was obtained using the 18-camera Mac3D motion analysis system (Motion Analysis Corp., Santa Rosa, CA, USA) (Figure 1). The marker trajectory data was then low-pass filtered through a Butterworth digital filter with a 6-Hz cut-off frequency.

Prior to taking measurements, we attached 41 reflective markers (diameters 1.9 cm and 1.3 cm for the right-hand segment) on the participants' body landmarks as previously described.[8] The participants were instructed to wear judo clothes designed to improve the visibility of the attached markers[14] as well as protective headgear to ensure safety during the measurement.

Figure 1. Motion capture setting and appearance of the participants during the measurements

The test protocol included three sets of backward breakfalls performed in response to osoto-gari throws by one tester (the thrower), a 3rd-degree black belt judoka with over 20 years' experience. As the thrower had a left-handed style, the left lower extremity of the participants was always swept first during the osoto-gari move (Figure 2).

After the breakfall task was completed, the participant was asked to gauge his perceived fear of injury and this was scored using a 5-rank Likert scale (1 "no fear at all," 2 "not much fear," 3 "can't say yes or no," 4 "felt some fear," and 5 "felt substantial fear"). All experienced participant but one answered either "no fear felt at all" or "not much fear felt." Four novice participants who answered "felt fear" were assigned to the Novice-F group, whereas four novice participants who answered "not much fear" were assigned to the Novice-NF group. The experienced participant who answered "felt some fear" and the two novice participants who answered "can't say yes or no" were eliminated from further analysis.

Data analysis

The 15-segment coordinate system consisted of the head, right/left upper arms, right/left forearms, right/left hands, upper trunk, lower trunk, right/left thighs, right/left shanks, and right/left feet. The joint centers of the neck, shoulder, knee, and ankle were each defined as the center of two markers across the joint; the hip joint center was estimated using the revised estimation method of the Clinical Gait Analysis Forum of Japan[15] The trunk was divided into the upper and lower trunk at the virtual trunk joint, a line connecting the two rib markers.

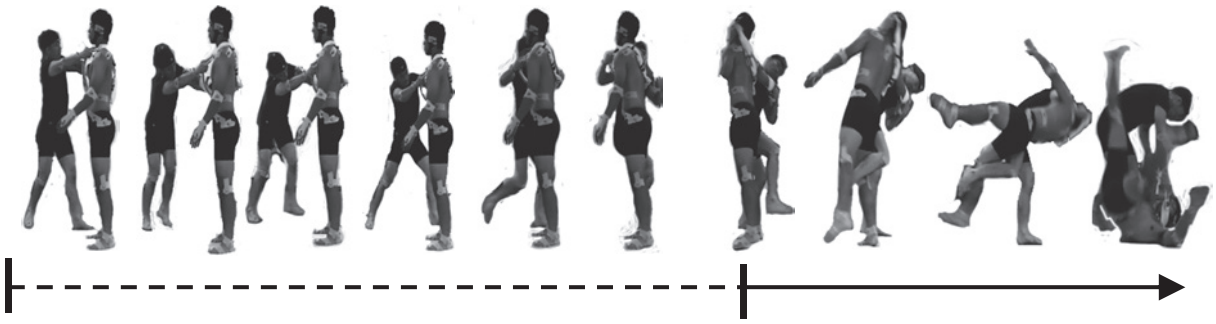

Figure 2. Sequence of movements in the osoto-gari technique: A solid arrow represents the analysing phase of the breakfall motion for osoto-gari.

The neck, trunk, right/left hip, and right/left knee joint angles in the sagittal plane were calculated as previously described by Koshida et al (2016)[8] using MATLAB (MATLAB R2016a, The Mathworks Inc., Natick, MA, USA). The directions of neck flexion, trunk flexion, hip flexion and knee flexion were defined as positive values. We also computed the peak neck angular momentum in the sagittal plane. Most head injuries from being thrown during judo occur when the occipital area of the head makes direct, hard contact with the judo mat. Our previous finding[8] indicated that the magnitude of peak neck extension momentum reflected the judoka's skill level for the breakfall, allowing the risk of head injury when being thrown with osoto-gari to be predicted. The neck extension momentum was defined in this study as the sum of the angular momentum around the virtual neck joint and the angular momentum around the center of the head.

The breakfall movement was analyzed from the time when the thrower's leg first touched the participant to the time when the participant's head was at the lowest position in the vertical axis (Figure 2). The kinematic data were normalized to 100% and then divided into 10% mark bins. Data for each 10% bin averaged over three trials was used for the statistical analysis. We confirmed the high repeatability of the angle–time curves for the neck, trunk, hips, and knees during the breakfall using the coefficient of multiple correlation,[16-17] which ranged from 0.79 to 0.99 in the experienced group, from 0.61 to 0.99 in the Novice-F group, and from 0.91 to 0.99 in the Novice-NF group.

Statistical analysis

All statistical analyses were performed with the free statistical software EZR version 1.33.[18] Differences between the three groups in joint angle changes and peak neck extension momentum during the backward breakfall movement were tested using the Kruskal–Wallis test. When a significant difference was found, a pairwise comparison was also performed using a Steel–Dwass test. Effect sizes were calculated using the product-moment correlation coefficient (r).[19] Statistical significance was set at 0.05. We also analyzed the joint angle curves qualitatively.

RESULTS

Joint angle–time angle curves during breakfall motion are illustrated in Figure 3. Kruskal–Wallis tests revealed significant differences among the experienced, Novice-F, and Novice-NF groups in the angle of the neck ($\chi^2 = 9.60$, $df = 2$, $P = 0.008$, $r = 0.25$), trunk ($\chi^2 = 13.40$, $df = 2$, $P = 0.001$, $r = 0.30$), left hip ($\chi^2 = 18.53$, $df = 2$, $P < 0.001$, $r = 0.35$), right knee ($\chi^2 = 27.66$, $df = 2$, $P < 0.001$, $r = 0.42$), and left knee ($\chi^2 = 11.67$, $df = 2$, $P = 0.003$, $r = 0.28$). However, we did not find any difference between the groups in right hip movement ($P > 0.05$).

Pairwise comparison using the Steel–Dwass test also revealed a significant difference only in the left knee angle ($P = 0.007$) between the Novice-N and Novice-NF groups. In addition, there were significant differences in neck angle between the experienced and Novice-NF groups ($P = 0.001$), trunk angle between the experienced and Novice-F groups ($P = 0.001$), and left hip ($P < 0.05$) and right knee angles ($P < 0.001$) between the experienced group and both novice groups.

Qualitative observations of the angle–time plots showed that the right knee angles in the Novice-F group were consistently greater than those in the Novice-NF group. In addition, we found remarkable differences in the left hip motion and the right knee motion. The mean left hip angles started flexing at approximately 20% of the way through the phase and the flexion angles kept increasing from about 60° to 80° in the both the Novice-F and Novice-NF groups, whereas the hip angles remained slightly flexed or in a neutral position until approximately halfway through the phase in the experienced judokas. In the novice judokas, the right knee flexion angle increased from the beginning of the throw and remained in a flexed position, whereas in the experienced judokas the knee flexion angle gradually changed and remained in a less flexed position throughout the entire motion.

The Kruskal–Wallis test also demonstrated significant differences among the three groups in peak head momentum in the sagittal plane ($P = 0.014$). The pairwise comparison test revealed that the momentum in the Novice-NF group was significantly greater than that in the experienced group ($P = 0.04$). In addition, the peak neck extension

momentum in the Novice-F group tended to be greater than that of the experienced group ($P = 0.06$); however, there was no significant difference between the Novice-F and Novice-NF groups ($P = 0.98$).

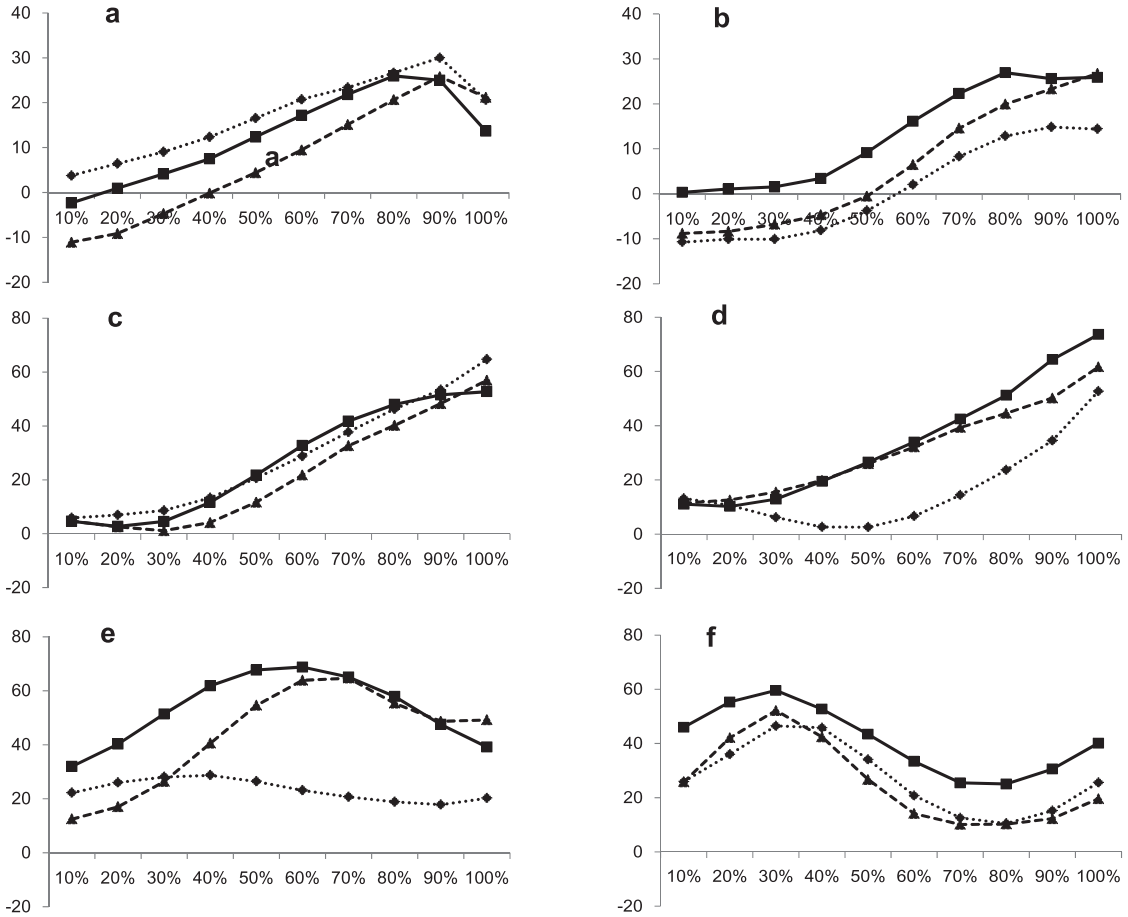

Figure 3. Mean angle–time plots in the 10% bins of (a) the neck, (b) the trunk, (c) the right hip, (d) the left hip, (e) the right knee and (f) the left knee during the breakfall motion. The solid lines represent the data for the Novice-F group (N = 4), the dashed lines represent the data for the Novice-NF group (N = 4), and the dotted lines represent the data for the experienced judokas (N = 7).

DISCUSSION

Judo-related head injuries among novice judokas have been gaining public attention in Japan.[1-3] Measures to prevent head injuries during judo participation should be developed to provide a safer environment for young or inexperienced judo participants. Previous evidence has indicated that perceived fear or anxiety may alter strategies in human movement1[0-13]; however, the association between perceived fear and breakfall kinematics has not previously been investigated. Our aim, therefore, was to investigate whether the fear of breakfalls for osoto-gari was associated with kinematics and possible risk factors for judo-related head injuries in novice judokas. Although our hypothesis was partially supported by the results, overall there were no differences in the evaluated kinematics between the novice judokas with and without fear of the breakfall.

The present results comparing the two groups of novice judokas demonstrated that perceived fear of the breakfall motion was related only to the kinematics in the knee of the swept side (i.e., the left side). Visual inspection of the joint angle curve showed a consistent difference between the two novice groups and the other group in the angle-change pattern from the beginning to the end of the motion. However, because there was no significant difference between the novice groups in other joint angle changes, the interpretation of the result warrants careful consideration.

A remarkable difference in neck extension momentum, one of the most relevant parameters in evaluating the risk of injury, was found between the novice judokas and the experienced judokas than between the two groups of novice judokas. This suggests that, in novice judokas, perceived fear of injury may not be associated with either breakfall kinematics or an increased risk of injury with osoto-gari. Thus, regardless of the presence of fear or anxiety toward the breakfall movement, teachers need to closely monitor the kinematics of the breakfall for osoto-gari.

The present study confirmed findings of our previous study regarding the change in the angle pattern of movement in novice judokas of the hip of the swept side (i.e., the left side in this study) and the knee opposite to the swept side (i.e., the right side in this study), demonstrating that these are robust kinematic characteristics. Previous studies have demonstrated that elderly individuals tend to flex their lower extremities as they squat during the descent phase of a backwards fall in an attempt to attenuate the impact force.[20-21)] The greater lower extremity flexion angles observed in the novice judokas may be a similar phenomenon. Neck and trunk flexion movements have attracted attention in relation to the current teaching method for judo backward breakfalls, which includes instructions such as “keep your eyes on the knot of the belt while performing the backward breakfall.” In addition to the importance of the neck, the present results also suggest that emphasis on maintaining a straight posture during the breakfall for osoto-gari may play a key role in teaching novice judo practitioners the proper technique.

There were several limitations in this study that provide direction for future research. First, an increased sample size would reduce the effects of individual variation on the results of the study. The perceived fear of the breakfall movement was evaluated only with a simple 5-rank Likert scale questionnaire. It has been suggested that anxiety can increase when performance is being evaluated, and that high anxiety and arousal in people in the early stage of learning may contribute to an increase in internal focus, which interferes with movement production.[13)] In the present study, we focused only on perceived fear of the breakfall movement for osoto-gari; however, any increase in anxiety and arousal occurring during the measurement may have affected the kinematics results. Using a more comprehensive psychological inventory for evaluating the anxiety status of the participants in future studies may provide greater insight into the fear–kinematics association in the breakfall movement for osoto-gari.

CONCLUSION

There was little difference between the novice judokas groups in the joint angle change and peak head angular momentum during breakfalls; in contrast, a difference was observed between the experienced and novice judokas,

suggesting that, in novice judokas, perceived fear of the movement may not be strongly associated with breakfall kinematics or the possible risk of injury.

ACKNOWLEDGEMENT

The study was supported by JSPS KAKENHI # 16k01668. The authors would like to thank all the participants for their contribution during the data collection. We also extend our appreciation to NAC image technology Inc., for their supports.

REFERENCES:

1. Nagahiro S, Mizobushi, Hondo H et al (2011) Severe head injuries during Judo practice. No Shinkei Geka. 39, 1139-1147.
2. Kamitani T, Nimura Y, Nagahiro Y et al (2013) Catastrophic head and neck injuries in judo players in Japan from 2003 to 2010.American Journal of Sports Medicine. 41 1915-1921.
3. All Japan Judo Federation (2015) Judo no anzen shido: jiko wo koshite husego (4th ed) [Safety instruction for judo:
   how to prevent an accident in judo]. Retrieved from http://www.judo.or.jp/wp-content/uploads/2013/08/print-shidou.pdfFederation. (Accessed 1st September, 2016)
4. Kano J (1994) Kodokan judo: The essential guide to judo by its founder Jigoro Kano. Tokyo: Kodansha International.
5. Imamura R, and Johnson B. (2003) A kinematic analysis of a judo leg sweep: major outer leg reap—osoto-gari. Sports Biomechanics. 2, 191-201
6. Hashimoto T, Ishii T, Okada N et al (2015) Impulsive force on the head during performance of typical ukemi techniques following different judo throws. Journal of Sports Sciences. 33, 1356-1365.
7. Murayama H, Hitosugi M, Motozawa Y et al (2014) Rotational acceleration during head impact resulting from different judo throwing techniques. Neurologia Medico-Chirurgica, 54, 374-378
8. Koshida S, Ishii T, Matsuda T et al (2016) Kinematics of judo breakfall for osoto-gari: consideration for head injury prevention. Journal of Sports Sciences, 21, 1-7.
9. Koshida S, Ishii T, Matsuda T et al (2015) Biomechanics of judo backward breakfall in adolescent judokas. Proceedings of XXXII international conference on biomechanics in sports, retrieved from http://isbs2015.sciencesconf.org/58634 (Accessed 1st September, 2016)
10. Carpenter MG, Frank JS, Silcher CP et al (2001) The influence of postural threat on the control of upright stance. Experimental Brain Research. 138, 210-218.
11. Huffman JL, Horslen BC, Carpenter MG et al (2009) Does increased postural threat lead to more conscious control of posture? Gait & Posture. 30, 528-532.
12. Rochat S, Bula CJ, Martin E et al (2010) What is the relationship between fear of falling and gait in well-functioning older persons aged 65-70 years? Archives of Physical Medicine & Rehabilitation. 91, 879-884.
13. Pijpers JR, Oudejans RRD, Bakker FC (2005) Anxiety-induced changes in movement behavior during the execution of a complex whole-body task. The Quarterly Journal of Experimental Psychology. 58, 421-445.

14. Ishii T, Ae M, Kobayashi Y et al (2012) Front-turn movement in seoi-nage of elite judo athletes. Proceedings of 30th International Conference on Biomechanics in Sports. 193–195.
15. Kurabayashi, J, Mochimaru M, Kouchi, M. (2003) Validation of the estimation methods for the hip joint center. Journal of the Society of Biomechanisms. 27, 29-36.
16. Mackey AH, Walt SE, Lobb GA et al (2005) Repeatability of upper and lower limb three-dimensional kinematics in children with hemiplegia. Gait and Posture. 22, 1-9.
17. Koshida S, Matsuda T, Kawada K (2011) Lower extremity biomechanics during kendo strike-thrust motion in healthy kendo athletes. Journal of Sports Medicine and Physical Fitness. 51, 357-365.
18. Kanda Y. Free statistical software: EZR (Easy R) on R commander, retrieved from http://www.jichi.ac.jp/saitama-sct/SaitamaHP.files/statmedEN.html (Accessed 1st September, 2016)
19. Mizumoto A, Takeuchi O (2008) Kenkyu ronbun ni okeru kokaryo no houkoku notameni – kiso gainen to cyui ten [Basics and Considerations for Reporting Effect Sizes in Research Papers]. Eigo Kyoikugaku Kenkyu. 31, 57-66.
20. Sandler R, Robinovitch SN (2001) An analysis of the effect of lower extremity strength on impact severity during a backward fall. Journal of Biomechanical Engineering. 123, 590–598.
21. Robinovitch SN, Brumer R, Maurer J (2004) Effect of the “squat protective response” on impact velocity during backward falls. Journal of Biomechanics. 37, 1329-1337.

（平成28年11月29日稿）
査読終了日　平成28年12月５日