

Chronic physical activity preserves efficiency of proprioception in postural control in older women

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Abstract—The purpose of this study was to compare the effects of proprioceptive disruption on postural control for participants of different ages according to their physical and/or sport activity levels. Two groups of young and old participants who practiced chronic physical and/or sport activities (young active [$n = 17$; average age 20.5 ± 1.1 yr] and old active [$n = 17$; average age 74.0 ± 3.8 yr]) and two groups of young and old participants who did not practice physical and/or sport activities (young sedentary [$n = 17$; average age 20.0 ± 1.3 yr] and old sedentary [$n = 17$; average age 74.7 ± 6.3 yr]) participated in the study. They were compared in a bipedal quiet stance reference condition and a bilateral Achilles tendon vibration condition. Center of foot pressure displacements and frequency analysis were compared between the groups. The results indicated that when proprioceptive information was disrupted, the postural control disturbance was more important for the old sedentary group than for the other groups. There were no differences between the old active group and the young sedentary group. Postural control was less altered for the young active group than for the other groups. Aging decreases the efficiency of postural control regardless of the assessment conditions. Physical and sport activities may compensate for the disturbing effects of proprioceptive perturbation through a better use of sensory information whatever the age of the participants.

Key words: aging, balance control, older, physical activity, postural control, proprioception, sensory manipulation, sports, tendon vibration, training.

INTRODUCTION

Proprioceptive impairment is associated with decreased functional ability and increased fall risk in older individuals [1–2]. Hence, the optimization or preservation of proprioception is crucial in rehabilitation. Indeed, proprioception largely contributes to postural regulation [3]. The contribution of proprioceptive sensory information appears to be reweighted according to environmental constraints and the available sensory information [4]. To quantify the weight of the sensory information in postural regulation, sensory manipulations were used as an experimental probe [4–7]. Brumagne et al. suggested, by means of vibration perturbation, that their older participants increased the weight of the ankle joint proprioception in postural regulation because of a decrease in the sensitivity of paraspinal muscle spindles or changes in the central processing of this afferent information [5]. This may reflect a refocusing of proprioceptive control of balance away from proximal and

Abbreviations: ANOVA = analysis of variance, COP = center of foot pressure.

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axial proprioception input to that derived from receptors in the ankle muscles [5]. Indeed, the involutions of the visual system [8–9], the vestibular system [10], the proprioceptive system [1,11] and the central processing mechanisms [12–14] induced by aging contribute to affect the dynamic regulation of the sensorimotor integration and decrease the efficiency of postural regulation [15].

However, regular and chronic physical activity is known to play a fundamental role in the improvement and preservation of balance ability in older participants [16–17] by repetitive stimulations of the sensorimotor systems. Furthermore, chronic sport activities can also improve postural regulation for young participants [6,18]. Thus, young and older individuals who practice chronic physical and/or sport activities likely demonstrate more efficient postural ability to withstand proprioceptive disturbance than other same-age individuals who do not practice physical and/or sport activities.

Hence, the main objectives of this study were to (1) emphasize the contribution of ankle proprioception on postural regulation according to the age and the physical and/or sport activity status of the participants and (2) clarify the resultant between the benefits induced by the chronic practice of physical activity and the involutions induced by aging on the postural regulation. Since aging and chronic physical activity have opposite effects on postural regulation, we hypothesized that the benefits induced by the chronic practice of physical activity may compensate for the involutions related to aging on postural ability to withstand challenging conditions, such as proprioceptive disruption. Moreover, some studies have reported differences between men and women in postural regulation [19–22]. Hence, to exclude the influence of an eventual sex effect, we have voluntarily chosen to focus only on women in this study.

METHODS

Participants

Sixty-eight healthy women shown to be free from any neurological, motor, or metabolic disorders after medical examination participated in the study. They were divided into four groups. Thirty-four young participants were divided into two groups: seventeen sporting participants (young active group) and seventeen nonsporting participants (young sedentary group). Thirty-four old participants were also divided into two groups: seventeen active participants (old active group) and seventeen nonactive participants (old sedentary group). Age and anthropometric data are presented in **Table 1**. After interviewing each subject, we included in the young active group persons who practiced sports in competition (e.g., swimming, gymnastics, handball, basketball, athletics) at at least a regional level and who trained three times a week (3 h or more a week) in addition to physical and/or sport activities practiced at college. We included in the young sedentary group persons who had not practiced physical and/or sport activities for at least 3 yr, except at college (less than 2 h a week). We included in the old active group persons who had regularly practiced physical activity (3 h or more a week) in a sports club (e.g., gymnastics, walking, dancing, aquarobics) for at least 3 yr. We included in the old sedentary group persons who had not practiced physical activity (at home or in a sports club) for at least 3 yr except for daily tasks. All the participants led independent lives. Exclusion criteria included a documented postural system disorder or a medical condition that might affect postural regulation, a neurological or a musculoskeletal impairment, or a current injury that made the participants unable to participate. We excluded persons who were not able to walk without a

Table 1.

Mean \pm standard deviation age and anthropometric data for four study groups.

Characteristic	Group				<i>F</i> and <i>p</i> -Value
	Young Active	Young Sedentary	Old Active	Old Sedentary	
Age (yr)	20.5 \pm 1.1	20.0 \pm 1.3	74.0 \pm 3.8*†	74.7 \pm 6.3*†	<i>F</i> = 1158.7, <i>p</i> < 0.001
Height (cm)	164.8 \pm 5.7	162.3 \pm 5.4	156.6 \pm 4.2*†	155.8 \pm 5.7*†	<i>F</i> = 11.8, <i>p</i> < 0.001
Weight (kg)	60.5 \pm 7.1	56.2 \pm 9.2	63.2 \pm 6.9	62.4 \pm 9.0	—
Foot Size (cm)	26.0 \pm 0.9	25.5 \pm 0.8	25.6 \pm 0.8	25.3 \pm 0.7	—

Note: Significant differences are included at level of 5 percent.

*Post hoc analysis difference from young active group.

†Post hoc analysis difference from young sedentary group.

walking stick and who were in a nursing home. Concerning the medical examination criteria, we excluded persons in the following categories: those who had experienced hip, knee, or ankle traumas in the past 2 yr; lesion of the foot skin support surface; or ankylosis of a large lower-limb joint (hip, knee, ankle); those who had disabling low vision despite correction or experienced chronic respiratory insufficiency requiring treatment with oxygen therapy; those undergoing medical treatment (bronchodilators, beta-blockers, corticosteroid, neuroleptics); and those with cardiovascular disease (coronary artery disease, myocardial infarction, congestive heart failure, permanent or paroxysmal heart rhythm disturbances, poorly controlled hypertension); neurological deficit; or disorders of higher functions, tone, sensitivity, and balance. We excluded from the young participant groups persons who were not taking contraceptive medication or who were pregnant.

Measurements

Participants were instructed to stand barefoot as motionless as possible on a force platform with three strain gauges (40 Hz frequency, 12 bit A/D conversion, Techno Concept; Cereste, France). They kept their arms next to their body, with their eyes fixed on a target (4 cm^2) 1.5 m in front of them at eye level. Their legs were straight and their feet formed a 30° angle relative to each other according to precise marks (intermalleolar distance of 9 cm).

They were tested in two conditions: a reference condition (i.e., quiet stance) and a sensory-manipulation condition. The main objective of this sensory-manipulation condition was to alter the proprioceptive information by means of tendinous vibratory stimuli, which modulate Ia afferences [23–24]. The tendon vibration was applied to the Achilles tendons of both legs (tendon vibration condition) by means of two inertial vibrators (VB 115, Techno Concept) secured with elastic bands. Vibration frequency was set at 40 Hz and the amplitude was 0.85 mm. Each condition lasted 20 s and the participants kept their eyes open. To avoid initial transients and anticipation behavior recording at the onset of the sensory disturbance, the sensory manipulation was set up in a range of 5 s before the recording of postural sway data.

POSTUROWIN software (Techno Concept) recorded the center of foot pressure (COP) displacement parameters that characterize the postural behavior. The COP surface (in millimeters squared) is an indicator of the subject's postural stability [25]; the smaller the COP surface area,

the better the stability. The COP velocity is an indicator of the subject's postural control [25]; the smaller the COP velocity, the better the postural control. The COP velocity can be detailed on the mediolateral axis in COP_x velocity (in millimeters per second) and on the anterior-posterior axis in COP_y velocity (in millimeters per second).

PosturoPro® software (Framiral; Cannes, France) analyzed stabilometric data to characterize spectral power density of the COP displacements by the wavelet transform. Application of the wavelet transform method to COP displacements provides a time-frequency chart of body sway and a three-dimensional representation of body sway [26–27]. The spectral analysis was computed for three frequency bands defined on the x -axis (frontal plane) and the y -axis (sagittal plane) as follows: 0.05–0.5 Hz (low frequencies LF_x and LF_y), 0.5–1.5 Hz (medium frequencies MF_x and MF_y), and 1.5–10 Hz (high frequencies HF_x and HF_y), expressed in arbitrary units [28]. This analysis characterizes the postural strategy used by the subjects. The low and medium frequencies are in domains mostly related to the visual and vestibular/somatosensory contribution to postural regulation, respectively [29–30]. As a rule, power in the higher band is not present in healthy subjects during quiet standing, but it can be seen with aging.

Statistical Analysis

Statistical analyses were performed with Statistica software (StatSoft Inc; Tulsa, Oklahoma). One-factor analysis of variance (ANOVA) was performed to determine whether there were differences among the four groups regarding age, anthropometric data, and COP displacements and spectral power density parameters in the reference condition. The effects of condition (reference and tendon vibration), age (young and old), and activity (active and sedentary) were tested using three-factor ANOVA with repeated measures on three factors. When a significant treatment effect occurred, Newman-Keuls post hoc analyses were used to test the difference among means. Results were considered significant at the level of 5 percent.

RESULTS

Age and Anthropometric Data

Results concerning age and anthropometric data are presented in **Table 1**. The results indicated, obviously, significant age differences between the young and old

participants. Furthermore, the young participant groups were taller than the old participant groups.

Reference Condition Comparisons Between Groups

Results concerning the reference condition comparisons among the four groups are presented in **Table 2**. Concerning COP displacements, the results showed that the COP surface and the COP_y velocity differed significantly among the four groups. The post hoc analyses indicated that COP_y velocity was higher for the old sedentary group than for the young sedentary and young active groups. Furthermore, the COP_y velocity was higher for the old active group than for the young sedentary and young active groups. The COP surface was lower for the young active group than for the old sedentary and old active groups.

As regards the spectral power density, LF_x, LF_y, MF_y, and HF_y differed significantly among the four groups. The post hoc analyses indicated that the spectral power density was higher for the old sedentary group than for the young sedentary group (MF_y, HF_y) and the young active group (LF_x, LF_y, MF_y, HF_y). It was also higher for the old active group than for the young sedentary group (LF_x, MF_y, HF_y) and the young active group (LF_x, LF_y, MF_y, HF_y).

Table 2.

Center of foot pressure (COP) parameters (mean \pm standard deviation [SD]) and spectral power density (mean \pm SD) in three frequency bands (on x- and y-axes) for four study groups in reference condition (i.e., quiet stance).

Parameter	Group				<i>F</i> and <i>p</i> -Value
	Young Active	Young Sedentary	Old Active	Old Sedentary	
Postural					
COP Surface	41.8 \pm 18.8	60.9 \pm 34.8	96.7 \pm 45.3*	91.9 \pm 80.6*	<i>F</i> = 4.6, <i>p</i> < 0.01
COP _x Velocity	3.9 \pm 0.8	4.4 \pm 1.0	4.5 \pm 1.4	4.0 \pm 1.2	—
COP _y Velocity	4.5 \pm 1.0	5.0 \pm 1.1	6.9 \pm 2.4*†	7.5 \pm 2.7*†	<i>F</i> = 9.3, <i>p</i> < 0.001
Spectral Power Density					
LF _x	52.8 \pm 4.2	54.6 \pm 6.8	60.1 \pm 5.6*†	57.9 \pm 6.7*	<i>F</i> = 5.2, <i>p</i> < 0.01
LF _y	58.4 \pm 4.2	61.0 \pm 5.6	64.5 \pm 5.0*	64.6 \pm 6.3*	<i>F</i> = 5.3, <i>p</i> < 0.01
MF _x	44.5 \pm 4.1	46.3 \pm 5.3	49.1 \pm 5.6	46.1 \pm 6.4	—
MF _y	47.3 \pm 4.4	49.6 \pm 4.6	55.1 \pm 5.2*†	54.7 \pm 6.0*†	<i>F</i> = 9.8, <i>p</i> < 0.001
HF _x	25.3 \pm 4.8	27.8 \pm 5.5	29.7 \pm 5.7	27.8 \pm 6.3	—
HF _y	31.1 \pm 3.8	32.3 \pm 4.4	37.7 \pm 6.0*†	38.1 \pm 6.9*†	<i>F</i> = 7.5, <i>p</i> < 0.001

Note: Significant differences included at level of 5 percent.

*Post hoc analysis difference from young active group.

†Post hoc analysis difference from young sedentary group.

HF = high frequency, LF = low frequency, MF = medium frequency.

Evolution of Center of Foot Pressure Displacements

Results concerning the evolution of the COP parameters are presented in **Table 3**. As regards the COP displacements, COP surface, COP_x velocity, and COP_y velocity presented a significant condition effect, indicating that the tendon vibration condition altered postural behavior for all the groups.

The COP surface and the COP_y velocity presented a significant condition \times age interaction, indicating that the vibration effects on postural behavior were altered according to age. The postural behavior was more disturbed for the older participants than for the younger participants in the tendon vibration condition.

The COP surface, the COP_x velocity, and the COP_y velocity presented a significant condition \times activity interaction, indicating that the vibration effects on postural behavior were altered according to the physical and/or sport activity status of the groups. Postural behavior was more disturbed for the sedentary participants than for the active participants in the tendon vibration condition.

The COP surface and the COP_y velocity presented a significant condition \times age \times activity interaction, indicating that the vibration effects on postural behavior were altered according to age and the physical and/or sport activity status of the groups.

The post hoc analyses revealed that most COP displacements increased more for the old sedentary group

Table 3.

Center of foot pressure (COP) parameters (mean \pm standard deviation) for four study groups in reference (REF) and Achilles tendon vibration (TV) conditions.

Postural Parameter	Condition	Group				F and p-Value			
		Young Active	Young Sedentary	Old Active	Old Sedentary	Condition	Condition \times Age	Condition \times Activity	Condition \times Age \times Activity
COP Surface	REF	41.8 \pm 18.8	60.9 \pm 34.8	96.7 \pm 45.3	91.9 \pm 80.6	$F = 81.3,$ $p < 0.001$	$F = 6.2,$ $p < 0.05$	$F = 16.5,$ $p < 0.001$	$F = 7.3,$ $p < 0.01$
	TV	126.8 \pm 69.5	190.7 \pm 106.6	174.7 \pm 66.7	393.1 \pm 247.8 ^{*†‡}				
COP _x Velocity	REF	3.9 \pm 0.8	4.4 \pm 1.0	4.5 \pm 1.4	4.0 \pm 1.2	$F = 355.1,$ $p < 0.001$	—	$F = 8.2,$ $p < 0.01$	—
	TV	8.7 \pm 1.7	9.6 \pm 1.5	8.9 \pm 2.2	11.2 \pm 4.2 ^{*‡}				
COP _y Velocity	REF	4.5 \pm 1.0	5.0 \pm 1.1	6.9 \pm 2.4	7.5 \pm 2.7	$F = 158.9,$ $p < 0.001$	$F = 21.5,$ $p < 0.001$	$F = 5.2,$ $p < 0.001$	$F = 5.5,$ $p < 0.05$
	TV	8.7 \pm 2.1	11.2 \pm 3.9	14.1 \pm 4.6 [*]	23.0 \pm 11.0 ^{*†‡}				

Note: Significant differences included at level of 5 percent.

*Post hoc analysis difference from young active group.

†Post hoc analysis difference from young sedentary group.

‡Post hoc analysis difference from old active group.

than for the old active group (COP surface, COP_x velocity, COP_y velocity), young sedentary group (COP surface, COP_y velocity), and young active group (COP surface, COP_x velocity, COP_y velocity). In addition, COP_y velocity was lower for the young active group than for the old active group.

Evolution of Spectral Power Density Parameters

Results concerning the evolution of spectral power density in the three frequency bands are presented in **Table 4**. As regards the spectral power density parameters, LF_x, LF_y, MF_x, MF_y, HF_x, and HF_y presented a significant condition effect, indicating that the tendon vibration condition altered postural strategy for all the groups.

LF_x, MF_x, MF_y, HF_x, and HF_y presented a significant condition \times activity interaction, indicating that the vibration effects on postural strategy were altered according to the physical and/or sport activity status of the groups. The postural strategy was more altered for the sedentary participants than for the active participants in the tendon vibration condition.

LF_x, MF_x, and HF_x presented a significant condition \times age \times activity interaction, indicating that the vibration effects on postural strategy were altered according to the age and the physical and/or sport activity status of the groups.

The post hoc analyses indicated that the spectral power density increased more for the old sedentary group than for the old active group (LF_x, MF_x, MF_y, HF_x, HF_y) and the young active group (LF_x, MF_y, HF_x, HF_y). In addition, spectral power density increased less for the young active group than for the young sedentary group (MF_y, HF_y).

DISCUSSION

The main results indicated that aging disturbed postural behavior in the reference and tendon vibration conditions. However, this disturbance was limited by the chronic practice of physical and/or sport activities in the condition where proprioception was disturbed for the old active group and the young active group. The chronic practice of physical and/or sport activities has positive effects on postural regulation efficiency, whatever the age of the participants. These effects render the old active group as efficient as the young sedentary group at withstanding proprioceptive disruption.

Postural behavior in the reference condition corroborates previous studies [31–32] that indicated that older groups were less stable than young groups, particularly in the anteroposterior direction. The involution of the sensory systems, central processing system, and motor output that occurs with aging constitutes the main factor altering postural regulation efficiency [14–15].

When proprioceptive information was altered (tendon vibration condition), postural behavior was disturbed for each group. Moreover, the postural behavior disturbance was more important for the old sedentary group than for the three other groups. There was no difference between the old active group and the young sedentary group when proprioceptive information was disrupted. The outcomes showed that the postural disturbance was less important for the young active group than for not only the old sedentary and old active groups but also the young sedentary group. These results indicate not only that aging decreases the efficiency of postural regulation to withstand proprioceptive

Table 4.

Spectral power density (mean \pm standard deviation) in three frequency bands (on x- and y-axes) for four study groups in reference (REF) and Achilles tendon vibration (TV) conditions.

Frequency Band	Condition	Group				F and p-Value			
		Young Active	Young Sedentary	Old Active	Old Sedentary	Condition	Condition \times Age	Condition \times Activity	Condition \times Age \times Activity
LF _x	REF	52.8 \pm 4.2	54.6 \pm 6.8	60.1 \pm 5.6	57.9 \pm 6.7	$F = 119.7,$ $p < 0.001$	—	$F = 5.4,$ $p < 0.05$	$F = 6.0,$ $p < 0.05$
	TV	61.9 \pm 4.2	63.5 \pm 5.1	63.8 \pm 3.9	68.6 \pm 5.9 ^{*†‡}				
LF _y	REF	58.4 \pm 4.2	61.0 \pm 5.6	64.5 \pm 5.0	64.6 \pm 6.3	$F = 81.0,$ $p < 0.001$	—	—	—
	TV	64.9 \pm 5.9	69.4 \pm 6.4	70.6 \pm 4.6	75.9 \pm 7.2				
MF _x	REF	44.5 \pm 4.1	46.3 \pm 5.3	49.1 \pm 5.6	46.1 \pm 6.4	$F = 326.4,$ $p < 0.001$	—	$F = 6.6,$ $p < 0.05$	$F = 6.0,$ $p < 0.05$
	TV	57.7 \pm 4.2	58.9 \pm 3.4	57.7 \pm 5.0	62.3 \pm 7.4 [‡]				
MF _y	REF	47.3 \pm 4.4	49.6 \pm 4.6	55.1 \pm 5.2	54.7 \pm 6.0	$F = 245.1,$ $p < 0.001$	—	$F = 9.6,$ $p < 0.01$	—
	TV	58.0 \pm 5.9	62.5 \pm 6.5 [*]	64.7 \pm 4.3	72.1 \pm 6.6 ^{*‡}				
HF _x	REF	25.3 \pm 4.8	27.8 \pm 5.5	29.7 \pm 5.7	27.8 \pm 6.3	$F = 365.3,$ $p < 0.001$	—	$F = 4.3;$ $p < 0.05$	$F = 7.7,$ $p < 0.01$
	TV	39.2 \pm 4.2	40.8 \pm 3.5	39.4 \pm 3.8	44.2 \pm 6.3 ^{*‡}				
HF _y	REF	31.1 \pm 3.8	32.3 \pm 4.4	37.7 \pm 6.0	38.1 \pm 6.9	$F = 227.9,$ $p < 0.001$	—	$F = 6.9,$ $p < 0.05$	—
	TV	41.3 \pm 5.4	45.3 \pm 6.7 [*]	49.0 \pm 4.5	55.9 \pm 7.6 ^{*‡}				

Note: Significant differences included at level of 5 percent.

*Post hoc analysis difference from young active group.

†Post hoc analysis difference from young sedentary group.

‡Post hoc analysis difference from old active group.

HF = high frequency, LF = low frequency, MF = medium frequency.

perturbation, but also that physical and sport activities may compensate for the disturbing effects related to age on the postural ability to withstand challenging conditions. The proprioceptive contribution in postural regulation or the ability to use other sensory inputs to withstand the sensory manipulation appeared to differ between the four groups.

In the present study, the older groups responded to vibration stimulation, demonstrating that the proprioceptive system was still effective. The vibration effects on postural behavior with aging are not uniform. Previous studies observed that the intensity of the postural response to vibration decreased and construed that this was due to a central level decline of the postural regulation system (in participants aged 60 to 86) [33] or an alteration of the stretch reflex (in participants aged older than 85) [34]. Conversely, Brumagne et al. observed that their older participants (mean age 63) were as sensitive as their young participants to vibration stimulation and suggested that the older age of participants in these previous studies could explain the weaker effects of the vibration stimulation [5]. The postural response to vibration stimulation is a complex multisegment synergy [35] that differs depending on the individual's age [36]. This response may be modulated by the integrity of and the

ability to use other sensory afferences (i.e., visual, vestibular, and cutaneous) [37–38]. In fact, the weight of proprioceptive contribution to spatial orientation [39] and postural regulation [5] may change according to the integrity of peripheral sensory systems. Brumagne et al. suggested that a refocusing of proprioceptive control of balance away from proximal and axial proprioception input to that derived from receptors in the ankle muscles would occur [5]. Hence, the contribution of ankle proprioception to postural regulation could be solicited more for the old sedentary group than for the three other groups for a simple task like maintaining quiet stance. This means that when proprioception was disrupted, the old sedentary group using proprioception in a dominating way might have saturated the proprioceptive system more quickly and was unable to compensate further postural disturbances compared with the other groups.

Nevertheless, postural behavior was significantly less disturbed by the proprioceptive disruption for the old active group than for the old sedentary group. Chronic physical activity involves repetitive stimulations of sensory systems that are known to enhance the efficiency, or at least limit the involution of, different neural loops involved in postural regulation induced by aging

[16,29,40–44]. Similarly, the postural disturbance was less important for the young active group than for the three other groups, which highlights that chronic practice of sports is also positive for the postural regulation of young individuals [6,45–47]. These studies suggested that physical and sport activities might improve the ability to withstand postural disturbance through a better use of the sensory information, whatever the age of the participants. When proprioception was disrupted, all the participant groups might have been compelled to rely more on other sensory inputs (e.g., visual and vestibular) to maintain postural stability. Since the old sedentary group did not benefit from the effects of physical activity, it would not have been able to compensate for the proprioceptive disruption by the use of the nondisrupted sensory inputs as efficiently as the three other groups. Conversely, chronic physical activity is likely to preserve the ability to reweight inaccurate proprioceptive information because no difference was found between the old active group and the young sedentary group in the tendon vibration condition. Physical activity may counteract aging's effect on the postural ability to withstand proprioceptive disruption. Moreover, chronic practice of sport activities resulted in a more efficient postural regulation for the young active group compared with the three other groups. The young active group probably used the non-disrupted sensory inputs to limit the postural disturbance more efficiently than the three other groups.

CONCLUSIONS

In conclusion, there is no doubt that aging decreases postural regulation ability in women. Although the efficiency of proprioception diminishes with age, the contribution of ankle proprioception to postural regulation might be solicited more for the old sedentary group than for the three other groups for a simple task like maintaining quiet stance. When proprioceptive information was disturbed by means of Achilles tendon vibration, the old sedentary group saturated proprioception more quickly than the three other groups. Furthermore, the old active group preserved the ability to withstand postural disturbance at the same level as the young sedentary group. Older women should regularly practice physical activities that particularly stimulate proprioception to preserve postural regulation efficiency. It would be interesting to determine the extent to which each physical activity influences the ability to withstand proprio-

ceptive disruption in female subjects. Physical therapists could thereby propose a physical activity adapted to the rehabilitation of the proprioception.

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