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Objective measures of physical activity in patients with chronic unilateral vestibular hypofunction, and its relationship to handicap, anxiety and postural stability

Hiroyuki Morimoto [a,b], Yuji Asai [a,c], Eric G. Johnson [d], Yoshinori Koide [a], Junichi Niki [b], Shigeki Sakai [b], Meiho Nakayama [e,*], Kayoko Kabaya [e], Ayako Fukui [e], Yoko Mizutani [f], Takehiko Mizutani [f], Yoshino Ueki [a], Jun Mizutani [a], Takatoshi Ueki [g], Ikuo Wada [a]

[a] Department of Rehabilitation Medicine, Graduate School of Medical Sciences, Nagoya City University, 1, Kawasumi, Mizuho-cho, Mizuho-ku, Nagoya 467-8601, Japan
[b] Department of Rehabilitation, Mizutani Hospital, 3-4-1, Kanayama-cho, Atsuta-ku, Nagoya 456-0002, Japan
[c] Department of Physical Therapy, School of Health Science, Nihon Fukushi University, 2-26, Higashihaemi-cho, Handa 475-0012, Japan
[d] Department of Physical Therapy, School of Allied Health Professions, Loma Linda University, 24951, Circle Drive, Loma Linda, CA 92354, USA
[e] Department of Otolaryngology, Head and Neck Surgery, Graduate School of Medical Sciences, Nagoya City University, 1, Kawasumi, Mizuho-cho, Mizuho-ku, Nagoya 467-8601, Japan
[f] Department of Orthopedics, Mizutani Hospital, 3-4-1, Kanayama-cho, Atsuta-ku, Nagoya 456-0002, Japan
[g] Department of Integrative Anatomy, Graduate School of Medical Sciences, Nagoya City University, 1, Kawasumi, Mizuho-cho, Mizuho-ku, Nagoya 467-8601, Japan

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ABSTRACT

Objective: Dizziness is one of the most common symptoms in the general population. Patients with dizziness experience balance problems and anxiety, which can lead to decreased physical activity levels and participation in their daily activities. Moreover, recovery of vestibular function from vestibular injury requires physical activity. Although there are reports that decreased physical activity is associated with handicap, anxiety, postural instability and reduced recovery of vestibular function in patients with chronic dizziness, these data were collected by self-report questionnaires. Therefore, the objective data of physical activity and the relationships between physical activity, handicap, anxiety and postural stability in patients with chronic dizziness are not clear. The purpose of this research was to objectively measure the physical activity of patients with chronic dizziness in daily living as well as handicap, anxiety and postural stability compared to healthy adults. Additionally, we aimed to investigate the relationships between physical activity, handicap, anxiety and postural stability in patients with chronic dizziness.
Methods: Twenty-eight patients with chronic dizziness of more than 3 months caused by unilateral vestibular hypofunction (patient group) and twenty-eight age-matched community dwelling healthy adults (healthy group) participated in this study. The amount of physical activity including time of sedentary behavior, light physical activity, moderate to vigorous physical activity and total physical activity using tri-axial accelerometer, self-perceived handicap and anxiety using questionnaires, and postural stability were measured using computerized dynamic posturography.

* Corresponding author.
E-mail address: m0719062139@gmail.com (M. Nakayama).

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Results: The results showed worse handicap, anxiety and postural stability in the patient group compared to the healthy group. Objective measures of physical activity revealed that the patient group had significantly longer time of sedentary behavior, shorter time of light physical activity, and shorter time of total physical activity compared to the healthy group; however, time of moderate to vigorous physical activity was not significantly different between groups. Moreover, there were correlations between physical activity and postural stability in the patient group, while there were no correlations between physical activity, handicap or anxiety in the patient group.
Conclusion: These results suggest that objectively measured physical activity of the patients with chronic unilateral vestibular hypofunction is lower compared to the healthy adults, and less active patients showed decreased postural stability. However, the details of physical activity and causal effect between physical activity and postural stability were not clear and further investigation is needed.

1. Introduction

Dizziness is one of the most common symptoms in the general population [1]. Patients with dizziness experience reduced quality of life [2], increased functional disability [3,4], and psychological impairments [5,6]. Balance problems are one of the most common symptoms associated with dizziness [7,8]. Patients with balance problems report walking disturbance [9], fear of falling, and falls [3,7,8]. As a result, physical activity levels and participation in daily activities are often reduced because patients with balance problem avoid behaviors and situations that cause fear of falling and falls [10,11]. Moreover, dizziness caused by vestibular deficits is a risk factor for developing psychiatric disorders such as anxiety [12,13]. Anxiety is associated with physical inactivity [14–16], and many patients with dizziness and anxiety report increased sick leave and avoid behaviors and environments that provoke symptoms [17–19]. Therefore, patients with chronic dizziness tend to be less active as a result of balance problems and anxiety [3,9,17–19].

Physical activity including head and body movements is important factor for recovering from vestibular injury [20–22], and also physical activity such as garden work, long walking, cycling, sports, gymnastic and dancing is beneficial for improving quality of life and decreasing risk of fall [23]. Therefore, understanding physical activity in daily living may be important for managing patients with dizziness.

Although there are many reports that physical activity is associated with chronic dizziness [3,4,9,17–19,23], these data were collected by interview or self-report questionnaires. Therefore, the details of physical activity and the relationships between physical activity, handicap, anxiety and postural stability in patients with chronic dizziness are not clear. The purpose of this research was to objectively measure the physical activity of patients with chronic dizziness in daily living as well as handicap, anxiety and postural stability compared to healthy adults. Additionally, we aimed to investigate the relationships between physical activity, handicap, anxiety and postural stability in patients with chronic dizziness.

2. Materials and methods

2.1. Participants

Twenty-eight patients with unilateral vestibular hypofunction (patient group) and twenty-eight age-matched community dwelling healthy adults (healthy group) participated in the study. Patients were recruited from Otolaryngology Department at Nagoya City University Hospital. Inclusion criteria were patients had unilateral vestibular hypofunction whose chronic dizziness persisted for more than 3 months. The vestibular function was measured by electronystagmography recordings during hot and cold air caloric testing, and unilateral vestibular hypofunction was defined as more than forty percent asymmetry of vestibular function. Exclusion criteria were patients with Ménière's disease due to possible fluctuations in vestibular function, and patients with other causes of vertigo, dizziness and balance problem such as cerebrovascular disease, neuromuscular disease, psychiatric disease and other problems that could affect dizziness, vertigo or balance. The healthy adults had no history of vertigo, dizziness, postural balance problem or psychiatric disease. Informed consent was obtained from all participants in compliance with Nihon Fukushi University Institutional Review Board protocol prior to beginning the study.

2.2. Evaluations

2.2.1. Physical activity measurement

Physical activity was assessed with the ActiGraph™ ActiSleep BT Monitor (ActiGraph LLC, Pensacola, FL, USA). The validity and reliability of this tool have been demonstrated [24,25]. This tool has a tri-axial accelerometer that provides dimensionless physical activity scores in counts that summarize the time period or epoch for sixty-second with sampling rate of 30 Hz. All participants were instructed to wear the device for seven days on their wrist of the non-dominant side [26] (Fig. 1), and remove it only during water-based activities (e.g., showering, bathing).

Fig. 1. Tri-axial accelerometer.
Participants were instructed to wear the device for seven days on their wrist of the non-dominant side, and remove it only during water-based activities.

The data were analyzed using the ActiLife™ software (version 6.11.8; ActiGraph LLC, Pensacola, FL, USA). Each minute of activity was categorized using intensity threshold values of counts per minute (cpm). The activity counts and the metabolic equivalents (METs), which is a physiological measure expressing the energy cost of physical activities, are highly correlated [24]. The following intensity-specific cut-points were applied to the raw data. Sedentary behavior (SB) was defined as activity below 100 cpm (<1–1.5 METs), a threshold that corresponds with activities such as sitting, watching TV, reclining or lying down. Light physical activity (LPA) was defined as activity between 100–1951 cpm (1.5–3 METs), a threshold that corresponds with activities such as hairstyling, very slow walking, and driving. Moderate to vigorous physical activity (MVPA) was defined as activity ≥1952 cpm (≥3 METs), a threshold that corresponds with activities such as making the bed, walking, or house cleaning [24,27]. Total physical activity (TPA) was defined as LPA plus MVPA. Both total time and percent time per day of SB, LPA, MVPA and TPA excluding non-wearing time and sleeping time were calculated.

2.2.2. Dizziness Handicap Inventory; DHI

The handicap related dizziness was evaluated using the Japanese version of DHI [28]. The DHI is one of the most frequently used questionnaires concerning self-perceived handicap related dizziness [29]. The validity and reliability of the original English and Japanese versions have been demonstrated [28,30]. The DHI is divided into 3 subscales; physical, emotional and functional. The DHI consists of 25 questions with 3 responses that evaluate the impact of dizziness or vertigo on quality of life [30].

2.2.3. Vertigo Symptom Scale-short form; VSS

Vertigo and/or dizziness related symptoms were evaluated using the Japanese version of VSS short form [31]. The validity and reliability of the Japanese version of VSS short form have been demonstrated [31]. The VSS short form divided into two subscales; vestibular-balance and autonomic-anxiety. The VSS short form consists of 15 questions with 4 responses that measure the frequency of vertigo, dizziness, unsteadiness, and concomitant autonomic/anxiety symptoms over the past month.

2.2.4. State-Trait Anxiety Inventory; STAI

Anxiety level was evaluated using the Japanese version of STAI [32]. The validity and reliability of the English and Japanese version of STAI have been demonstrated [32,33]. The STAI is one of the most widely used anxiety measures, and a psychometric self-report measurement with two sections; state scale and trait scale, including 20 items with 4 responses each. The state subscale measures anxiety at the present moment, and the trait subscale measures relatively stable individual propensity [34].

2.2.5. Computerized Dynamic Posturography; CDP

Postural stability was measured using a CDP system (Balance Master®, NeuroCom). The validity and reliability of the CDP system have been demonstrated [35,36]. Participants stood on the CDP force plate in four different conditions; firm surface with eyes open (Condition 1), firm surface with eyes closed (Condition 2), foam surface with eyes open (Condition 3) and foam surface with eyes closed (Condition 4). Three trials were taken for each condition and a calculated mean velocity in degrees per second of body sway was determined.

2.3. Statistical analysis

Statistical analysis was performed using chi-square test for difference of gender, unpaired t-test for differences of age, height, weight, BMI, physical activity, DHI, VSS, STAI and CDP between groups. Pearson's correlation coefficient for correlations between physical activity and the other outcomes including DHI, VSS, STAI and CDP in the patient group were also performed. All analyses were performed using SPSS ver. 17.0., and statistical significance was defined as $p \leq 0.05$.

3. Results

3.1. Participant characteristics

The characteristics of participants including gender, age, height, weight, body mass index (BMI) and duration of symptom are shown in Table 1. There were no significant differences of gender, age, height, weight and BMI between groups (Table 1).

3.2. Physical activity

SB was 315.5 ± 57.7 min and 49.1 ± 7.0% in the patient group, and 283.6 ± 54.2 min and 43.7 ± 6.6% in the healthy group. There were significant differences in both time and percent SB between groups (Table 1).

LPA was 249.9 ± 48.9 min and 38.8 ± 5.5% in the patient group, and 274.9 ± 46.3 min and 42.5 ± 5.4% in the healthy group. There were significant differences in both time and percent LPA between groups (Table 1).

MVPA was 141.7 ± 67.3 min and 12.0 ± 5.4% in the patient group, and 162.9 ± 55.5 min and 13.8 ± 4.6% in the healthy group. There were no significant differences in either time or percent MVPA between groups (Table 1).

TPA was 391.6 ± 88.0 min and 50.7 ± 7.0% in the patient group, and 437.8 ± 79.6 min and 56.3 ± 6.6% in the healthy group. There were significant differences in either time or percent TPA between groups (Table 1).

3.3. DHI

In the patient group, DHI Physical, DHI Emotional, DHI Functional and DHI Total were 12.4 ± 6.9 points, 11.9 ± 8.3 points, 14.0 ± 8.7 points and 41.3 ± 21.3 points respectively. In the healthy group, DHI Physical, DHI Emotional, DHI Functional and DHI Total were 0.6 ± 1.2 points, 0.7 ± 1.5 points, 0.7 ± 1.1 points and 2.1 ± 2.9 points respectively. There were significant differences in DHI Physical, DHI Emotional, DHI Functional and DHI Total between groups (Table 1).

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Table 1
Differences of gender, age, height, weight, BMI, physical activity, DHI, VSS, STAI and postural stability in both patient group and healthy group.

	Patient group (n = 28)	Healthy group (n = 28)	p-Value
Gender (male:female)	12:16	10:18	0.58[a]
Age (years)	63.5 ± 15.6	65.0 ± 13.4	0.70[b]
Height (cm)	157.9 ± 7.8	158.6 ± 8.3	0.74[b]
Weight (Kg)	54.9 ± 9.1	55.5 ± 8.2	0.83[b]
BMI	22.1 ± 3.5	22.0 ± 2.7	0.97[b]
Duration of symptom (months)	18.1 ± 14.6	–	–
Time of SB (min)	315.5 ± 57.7	283.6 ± 54.2	**<0.05**[b]
Time of LPA (min)	249.9 ± 48.9	274.9 ± 46.3	**<0.05**[b]
Time of MVPA (min)	141.7 ± 67.3	162.9 ± 55.5	0.21[b]
Time of TPA (min)	391.6 ± 88.0	437. 8 ± 79.6	**<0.05**[b]
Percent SB (%)	49.1 ± 7.0	43.7 ± 6.6	**<0.05**[b]
Percent LPA (%)	38.8 ± 5.5	42.5 ± 5.4	**<0.05**[b]
Percent MVPA (%)	12.0 ± 5.4	13.8 ± 4.6	0.17[b]
Percent TPA (%)	50.7 ± 7.0	56.3 ± 6.6	**<0.05**[b]
DHI Physical (points)	12.4 ± 6.9	0.6 ± 1.2	**<0.05** [b]
DHI Emotional (points)	11.9 ± 8.3	0.7 ± 1.5	**<0.05**[b]
DHI Functional (points)	14.0 ± 8.7	0.7 ± 1.1	**<0.05**[b]
DHI Total (points)	41.3 ± 21.3	2.1 ± 2.9	**<0.05**[b]
VSS Vestibular-Balance (points)	9.6 ± 6.4	0.3 ± 0.8	**<0.05**[b]
VSS Autonomic-Anxiety (points)	4.7 ± 4.9	1.2 ± 1.4	**<0.05**[b]
VSS Total (points)	13.3 ± 8.1	1.5 ± 1.8	**<0.05**[b]
STAI, State anxiety score (points)	48.5 ± 7.6	36.7 ± 8.1	**<0.05**[b]
STAI, Trait anxiety score (points)	47.3 ± 9.7	38.7 ± 8.3	**<0.05**[b]
CDP, Condition 1 (degrees/second)	0.3 ± 0.1	0.3 ± 0.1	0.79[b]
CDP, Condition 2 (degrees/second)	0.5 ± 0.2	0.4 ± 0.1	0.24[b]
CDP, Condition 3 (degrees/second)	0.9 ± 0.4	0.7 ± 0.1	**<0.05**[b]
CDP, Condition 4 (degrees/second)	3.7 ± 1.8	2.0 ± 0.5	**<0.05**[b]

Values are mean ± SD.
BMI, body mass index; SB, sedentary behavior; Light PA, light physical activity; MVPA; moderate to vigorous physical activity; TPA, total physical activity; DHI, Dizziness Handicap Inventory; VSS: Vertigo Symptom Scale; STAI: State-Trait Anxiety Inventory; CDP: Computerized Dynamic Posturography; SD: standard deviation.
Superscript alphabet “a” indicates Chi-square test, “b”, unpaired t-test.
Numbers with significance $p < 0.05$?are in bold characters.

3.4. VSS

In the patient group, VSS Vestibular-Balance, VSS Autonomic-Anxiety and VSS Total were 9.6 ± 6.4 points, 4.7 ± 4.9 points and 13.3 ± 8.1 points respectively. In the healthy group, VSS Vestibular-Balance, VSS Autonomic-Anxiety and VSS Total were 0.3 ± 0.8 points, 1.2 ± 1.4 points and 1.5 ± 1.8 points respectively. There were significant differences in VSS Vestibular-Balance, VSS Autonomic-Anxiety and VSS Total between groups (Table 1).

3.5. STAI

State anxiety score was 48.5 ± 7.6 points in the patient group and 36.7 ± 8.1 points in the healthy group. Trait anxiety score was 47.3 ± 9.7 points in the patient group and 38.7 ± 8.3 points in the healthy group. There were significant differences in both State and Trait anxiety scores between groups (Table 1).

3.6. CDP

In the patient group, Conditions 1–4 were 0.3 ± 0.1 degrees/second, 0.5 ± 0.2 degrees/second, 0.9 ± 0.4 degrees/second and 3.7 ± 1.8 degrees/second respectively. In the healthy group, Conditions 1–4 were 0.3 ± 0.1 degrees/second, 0.4 ± 0.1 degrees/second, 0.7 ± 0.1 degrees/second and 2.0 ± 0.5 degrees/second respectively. There were significant differences in condition 3 and 4 between groups (Table 1).

3.7. Correlations of physical activity

There were correlations between MVPA, TPA and CDP condition 4 in the patient group (Table 2). There were no correlations between physical activity and other outcome measures including DHI, VSS and STAI in the patient group (Table 2).

4. Discussion

Objective measures of physical activity, handicap, anxiety and postural stability between patients with chronic unilateral vestibular hypofunction and healthy adults were investigated, as well as relationships between objective measures of physical activity, handicap, anxiety and postural stability in patient with chronic unilateral vestibular hypofunction. The patient group demonstrated higher handicap, higher anxiety and decreased postural stability compared to the healthy group. Objective measures of physical activity revealed that SB was significantly

Table 2
Correlations between physical activity and DHI, VSS, STAI and CDP in patient group.

	DHI Physical	DHI Emotional	DHI Functional	DHI Total	VSS Vestibular-balance	VSS Autonomic-anxiety	VSS Total	STAI State	STAI Trait	CDP Condition 1	CDP Condition 2	CDP Condition 3	CDP Condition 4
Time of SB	r = 0.058	r = 0.044	r = −0.034	r = 0.22	r = 0.018	r = 0.290	r = 0.172	r = 0.122	r = 0.246	r = −0.036	r = 0.059	r = 0.041	r = 0.002
	p = 0.771	p = 0.824	p = 0.863	p = 0.913	p = 0.927	p = 0.135	p = 0.382	p = 0.538	p = 0.207	p = 0.857	p = 0.767	p = 0.834	p = 0.994
Time of LPA	r = −0.105	r = 0.087	r = 0.014	r = 0.006	r = −0.035	r = −0.029	r = −0.41	r = 0.156	r = 0.056	r = −0.142	r = 0.121	r = 0.075	r = −0.085
	p = 0.595	p = 0.659	p = 0.943	p = 0.977	p = 0.859	p = 0.883	p = 0.835	p = 0.428	p = 0.776	p = 0.471	p = 0.54	p = 0.705	p = 0.667
Time of MVPA	r = −0.100	r = −0.077	r = −0.292	r = −0.18	r = −0.150	r = −0.130	r = −0.178	r = −0.035	r = −0.197	r = −0.335	r = −0.2	r = −0.373	**r = −0.530**
	p = 0.611	p = 0.696	p = 0.131	p = 0.361	p = 0.447	p = 0.511	p = 0.366	p = 0.86	p = 0.315	p = 0.081	p = 0.309	p = 0.5	**$p < 0.05$**
Time of TPA	r = −0.135	r = −0.11	r = −0.216	r = −0.134	r = −0.134	r = −0.115	r = −0.159	r = 0.060	r = −0.119	r = −0.335	r = −0.086	r = −0.244	**r = −0.452**
	p = 0.493	p = 0.957	p = 0.272	p = 0.496	p = 0.497	p = 0.559	p = 0.420	p = 0.762	p = 0.546	p = 0.081	p = 0.665	p = 0.211	**$p < 0.05$**
Percent SB	r = 0.162	r = 0.025	r = 0.897	r = 0.096	r = 0.126	r = 0.220	r = 0.211	r = 0.026	r = 0.204	r = 0.201	r = 0.053	r = 0.147	r = 0.292
	p = 0.411	p = 0.898	p = 0.661	p = 0.626	p = 0.522	p = 0.260	p = 0.282	p = 0.895	p = 0.297	p = 0.306	p = 0.79	p = 0.456	p = 0.131
Percent LPA	r = −0.099	r = 0.022	r = 0.145	r = 0.035	r = 0.001	r = −0.167	r = −0.091	r = 0.055	r = −0.207	r = 0	r = 0.09	r = 0.146	r = 0.126
	p = 0.617	p = 0.911	p = 0.463	p = 0.859	p = 0.994	p = 0.396	p = 0.647	p = 0.78	p = 0.892	p = 0.998	p = 0.649	p = 0.459	p = 0.522
Percent MVPA	r = −0.118	r = −0.083	r = −0.274	r = −0.18	r = −0.169	r = −0.126	r = −0.189	r = −0.052	r = −0.208	r = −0.311	r = −0.185	r = −0.354	**r = −0.517**
	p = 0.551	p = 0.675	p = 0.159	p = 0.361	p = 0.391	p = 0.523	p = 0.335	p = 0.792	p = 0.288	p = 0.107	p = 0.346	p = 0.065	**$p < 0.05$**
Percent TPA	r = −0.168	r = −0.046	r = −0.097	r = −0.110	r = −0.128	r = −0.227	r = −0.126	r = 0.003	r = −0.181	r = −0.238	r = −0.072	r = −0.157	r = −0.298
	p = 0.394	p = 0.815	p = 0.624	p = 0.576	p = 0.515	p = 0.245	p = 0.270	p = 0.987	p = 0.358	p = 0.222	p = 0.717	p = 0.424	p = 0.123

SB, sedentary behavior; LPA, light physical activity; MVPA, moderate to vigorous physical activity; TPA, total physical activity; DHI, Dizziness Handicap Inventory; VSS, Vertigo Symptom Scale; STAI, State-Trait Anxiety Inventory; CDP, Computerized Dynamic Posturography; r, Pearson's correlation coefficient.
Numbers with significance $p < 0.05$?are in bold characters.

longer and both LPA and TPA were significantly shorter in the patient group, while MVPA was not significantly different between groups. Moreover, there were correlations between physical activity and postural stability, while there were no correlations between physical activity, DHI, VSS, and STAI in the patient group.

There are several reports describing the physical activity among patients with dizziness in their daily living, however physical activity of patients with dizziness was evaluated by interview or self-reported questionnaires [3,4,9,17–19,23]. There were weak correlations between interview or self-reported questionnaire and accelerometer measurements of physical activity, and correlation coefficients were between 0.20 and 0.46 [37]. Therefore, details of physical activity in their daily living were not clear. The present study showed similar results of previous reports concerning patients with dizziness and inactivity [3,4,9,17–19,23]. Patients with dizziness tend to be less active because they avoid behaviors and environments that provoke their symptoms [3,17–19]. In the present study, the patients with chronic unilateral vestibular hypofunction demonstrated longer SB, shorter LPA and shorter TPA than the healthy adults. Moreover, the patient group showed same MVPA level compared with the healthy group. Some household activities are applicable to activities above 3 METs, such as window cleaning, vacuuming, sweeping and mopping [38,39]. We speculated that the estimated intensities of MVPA of both the patient and healthy groups in the present study were necessary movements for their daily living leading to similar levels in both groups.

Psychiatric comorbidities such as anxiety in patients with dizziness have been broadly described [5,6]. Vestibular deficits are one of the risk factors for the development of secondary psychiatric disorders [12,13], and an estimated 10–57% of patients with dizziness report symptoms of anxiety disorder [5,6,12]. The bidirectional relationships between neuro-otologic conditions and psychological problems have been confirmed [40]. Anxiety also can affect ocular motor reflexes and gaze stability control [41]. There is evidence that vestibular nuclei are connected to parabrachial nucleus, which is directly connected to the regions that control the manifestation of anxiety [42]. Moreover, anxiety can negatively impact vestibular system and it can prolong dizziness [43]. The patients with chronic unilateral vestibular hypofunction in the present investigation demonstrated higher anxiety scores and it may have influenced their dizziness.

In the present study, the patients with chronic unilateral vestibular hypofunction demonstrated increased postural instability compared to the healthy adults. Postural instability is one of the most frequently symptoms for dizziness [7,8]. The vestibular system plays a significant role in maintaining balance [44]. All patients in this study had unilateral vestibular hypofunction, therefore the patients with chronic unilateral vestibular hypofunction showed decreased postural stability compared with the healthy adults. Moreover, there are reports that postural stability has a relationship to physical activity [11,45] and also to anxiety [46,47]. Less physical activity could negatively affect lower extremity functions [48,49] that could affect postural stability [50], and anxiety could affect sensory inputs involved in balance performance [47]. Therefore, the postural stability in the patients with chronic unilateral vestibular hypofunction may be affected by less physical activity and anxiety [11,45–50].

In the present study, the patients with chronic unilateral vestibular hypofunction demonstrated longer periods of SB, shorter period of both LPA and TPA, higher handicap, higher anxiety, and decreased postural stability compared to the healthy adults. It is known that anxiety, inactivity and dizziness can interact with each other [22], and also the bidirectional effect of dizziness-anxiety [40] and anxiety-inactivity [14] has been reported. Also, there are relationships of decreased postural stability to anxiety [46,47] and physical activity [11,45]. These conditions may contribute to patients falling into a vicious cycle of dizziness, anxiety and inactivity [17,22,43], and it may negatively impact to recovery for dizziness [17,22,43]. In the present study, the results showed that the relationships between physical activity and postural stability were seen in the patient group. The results suggest that more physically active patients have better postural stability, which supported previous findings [11,45]. It has been reported that physical activity can negatively affect lower extremity functions [48,49] and lead to postural instability [50]. This might also be the case with the patients in the present study. Although there were relationships between physical activity and postural stability, there were no relationships between physical activity and anxiety. These results did not support previous reports of relationships between physical activity and anxiety [14,15]. These reports described the relationships between physical activity and anxiety in participants without dizziness. Therefore, there might be differences of the health status between the participants without dizziness in the previous reports and the patients with chronic dizziness in the present study. Moreover, there is one report that patients with dizziness experienced handicap and poor quality of life [2] because they avoid the situations and the movements that cause dizziness [3,17–19], and 41–72% of 84 patients complained about restricted activity [19]. In the present study, although the patients with chronic unilateral vestibular hypofunction frequently experienced handicap and symptoms related to dizziness, they showed same MVPA level compared to the healthy adults and the patients could move freely. Additionally, no correlations between physical activity, DHI and VSS were investigated. In the present study, the physical activity was objectively measured, although the physical activity was subjectively measured in the previous study [3,4,9,17–19,23]. Therefore, the results in the present study might show no correlations between physical activity, handicap and anxiety.

There were several limitations in this study. Although the observed difference in SB, LPA and TPA were statistically significant, the percent difference of the results was small, and larger sample sizes are needed to determine clinically significance. In the present study, the amount of physical activity in daily living was objectively measured by the accelerometer placed on their wrist. There are reports that patients with dizziness tend to move slowly [51] and decreasing their head movement while they are moving [52]. Although there is a moderate linear relationship between wrist- and hip-worn accelerometer among older adults in daily living conditions [53], the actual head or trunk movements that could highly affect our results were not measured. The patients with chronic unilateral vestibular hypofunction in the present study may have learned to modify their head or trunk movement strategies to reduce symptom provocation, and they may use their hands without head or trunk movements in their daily living. Thus, the actual head or trunk movements in their daily living were not clear. Moreover, details of physical activity such as daily variation or patterns were not measured, and the study design was cross sectional. Therefore, more details of physical activity in their daily living and the causal effect between physical activity and postural stability were not clear in this study and further investigation is needed.

The present investigation was novel in objectively quantifying physical activity among patients with chronic unilateral vestibular hypofunction in their daily living. Our findings may be an important consideration for clinicians managing patients with chronic dizziness concerning patient education about their physical activity. Encouraging patients with chronic dizziness to spend less time performing sedentary behavior and more time performing physical activity in their daily living may be an important vestibular rehabilitation strategy.

5. Conclusion

The differences of physical activity in daily living as well as handicap, anxiety and postural stability between patients with chronic unilateral vestibular hypofunction and healthy adults were investigated. Additionally, relationships between physical activity, handicap, anxiety and postural stability were also explored.

The result showed worse handicap, anxiety and postural stability in the patient group compared to the healthy group. Objective measures of physical activity revealed that the patient group had significantly longer time of SB, shorter time of LPA and shorter time of TPA compared to the healthy group; however, time of MVPA was not significantly different between groups. Moreover, there were correlations between physical activity and postural stability in the patient group; however, there were no correlations between physical activity, handicap and anxiety in the patient group.

These results suggest that objectively measured physical activity of the patients with chronic unilateral vestibular hypofunction is lower compared to the healthy adult, and less active patients showed decreased postural stability. However, the details of physical activity and causal effect between physical activity and postural stability were not clear and further investigation is needed.

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