Effects of walking exercise on nocturia in the elderly

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ABSTRACT

We investigated whether nocturia in the elderly was improved by walking exercise, which involved walking rapidly for 30 min or more in the evening or night for 8 weeks. A questionnaire related to micturition and exercise, blood pressure, body composition analysis, blood biochemistry tests, and urinalysis were performed before and after 8 weeks of exercise to investigate the effects of walking. Thirty men (71 years old on average) continued the walking exercise for long enough to undergo evaluation. The number of episodes of nocturia decreased significantly (p < 0.001) from 3.3 ± 0.7 to 1.9 ± 0.8 after 8 weeks of walking exercise. The daytime urinary frequency, blood pressure, body weight, body fat ratio, edema ratio, serum catecholamines, triglycerides, and total cholesterol were also decreased. After 8 weeks of exercise, 20 of the subjects (67%) stated that sleep was deeper than before exercise. Assessment of the overall improvement showed that excellent or good results were obtained in 18 patients (60%). The main factor related to the influence of walking exercise on nocturia was that sleep became deeper, which increased the arousal threshold bladder volume. Walking exercise may also have a preventive effect on lifestyle-related diseases.

Nocturnal urinary frequency (nocturia) is a common symptom in the elderly, and it is also one of the most troublesome urologic symptoms (2, 3). Nocturia may lead to sleep disturbance that causes daytime fatigue, as well as worsening the quality of life (QOL) (1–3). Many individuals who suffer from nocturia, particularly elderly men, have other lower urinary tract symptoms such as urinary frequency, poor stream, and urgency due to benign prostatic hyperplasia (BPH) (10). In women, similar symptoms are often considered to result from aging or childbirth (24). However, various other factors may contribute to nocturia, including pathological conditions such as cardiovascular diseases, diabetes mellitus, anxiety disorders, and primary sleep disorders, as well as numerous behavioral and environmental factors (23).

With respect to the medical treatments of nocturia, administration of anticholinergics (17), arginine vasopressin (15), or hypnotics before sleep (12) was reported to be useful. In patients with BPH, administration of adrenergic alpha-1 receptor antagonists improves voiding disorders and also reduces urinary frequency including nocturia (16). Therefore, dysfunction of the cholinergic and adrenergic nervous systems, sleep problems, or an abnormal water balance may be possible causes of nocturia. We hypothesized that walking exercise in the evening or night might be suitable for improvement of these conditions, because exercise induces sweating and may also lead to deeper sleep. In addition, walking exercise has been reported to decrease the blood pressure in patients with hypertension (5, 7). Ac...
Accordingly, we examined the effect of walking exercise in the evening or night on the occurrence of nocturia and on body composition in elderly men with nocturia.

MATERIALS AND METHODS

The subjects were selected from outpatients who consulted the Department of Urology at our University Hospital or an affiliated hospital between January 2000 and January 2006. Patients who met the following criteria were enrolled: 1) their lower urinary tract symptoms, except for nocturia, were controlled by medication that had not been changed within the previous 8 weeks; 2) they had nocturia and the mean frequency of urination at night was \( \geq 2 \) times; 3) they had no neurological abnormalities and no limitation of movement; 4) they did not have hepatic dysfunction, renal dysfunction, or cardiovascular disease; and 5) although their lifestyle was sedentary, they were able to walk rapidly for 30 min or more in the evening or at night every day for 8 weeks. Patients having bacterial cystitis, bacterial prostatitis, urinary tract cancer, hematuria, or proteinuria were excluded. A total of 47 men gave consent to this study and were enrolled. All 47 male patients had benign prostatic hyperplasia with or without non-bacterial chronic prostatitis and were being treated with adrenergic alpha 1 receptor antagonists and/or herbal medicines. Their residual urine volume was \(< 20 \) mL on abdominal ultrasonography.

We examined the underlying disease, concomitant illnesses, medications, average number of daytime urinations over one week, average number of nocturnal urinations during the sleeping period, QOL score (happy: 0, satisfied: 1, almost satisfied: 2, not satisfied/not dissatisfied: 3, slightly dissatisfied: 4, dissatisfied: 5, unhappy: 6), blood pressure, serum total protein (TP), albumin (ALB), aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), cholinesterase (ChE), blood urea nitrogen (BUN), creatinine (CRE), triglycerides (TG), total cholesterol (T-Chol), human atrial natriuretic peptide (HANP), brain natriuretic peptide (BNP), adrenalin (AD), noradrenalin (NA), dopamine (DP), and urinalysis findings before and after the 8 weeks of walking exercise. By using a body composition analyzer (InBody2; MP Japan Co., Ltd. Tokyo), the body weight, body fat ratio, and edema ratio (extracellular water volume/total body water volume) were also measured at 10–12 AM before and after the 8 weeks of walking exercise. After 8 weeks, an urologist (KS) comprehensively evaluated each patient’s satisfaction with their exercise program and assigned them to one of four categories (excellent, good, fair, and unchanged or worse).

Results are reported as the mean \( \pm \) standard deviation (SD). Student’s paired \( t \)-test was used for statistical analysis, and \( p < 0.05 \) was considered to indicate statistical significance.

RESULTS

Among the 47 patients, there were 17 patients who did not perform walking exercise properly, so the other 30 patients were evaluated. These 30 patients performed walking exercise daily or almost every day (\( \geq 5 \) times a week). Their average age was \( 71 \pm 6 \) years (range: 65–79 years). Eleven of the 30 patients were taking antihypertensive agents.

After walking exercise was performed for 8 weeks, the frequency of nocturia was significantly (\( p < 0.001 \)) decreased from 3.3 \( \pm \) 0.7 times to 1.9 \( \pm \) 0.8 times (Table 1). The frequency of daytime urination was slightly, but significantly (\( p < 0.001 \)), decreased from 9.1 \( \pm \) 1.4 times to 8.4 \( \pm \) 1.2 times. The average of QOL score was significantly (\( p < 0.001 \)) improved from 4.4 \( \pm \) 0.7 points (4 to 6 points) to 2.2 \( \pm \) 1.1 points (0 to 4 points). Systolic and diastolic blood pressures also showed a significant (both \( p < 0.001 \)) decrease.

Body composition analysis (Table 1) showed that the body weight was significantly (\( p < 0.001 \)) decreased from 63.5 \( \pm \) 5.7 kg to 62.7 \( \pm \) 5.3 kg after 8 weeks of exercise. The body fat ratio was also significantly (\( p < 0.001 \)) decreased from 25.1 \( \pm \) 4.6% to 25.1 \( \pm \) 4.6%. The edema ratio was slightly, but significantly (\( p < 0.001 \)), decreased from 0.357 \( \pm \) 0.009 to 0.350 \( \pm \) 0.007.

### Table 1. Body composition, blood pressure (BP), urinary frequency (UF) and QOL score before and after walking exercise

<table>
<thead>
<tr>
<th></th>
<th>Body weight (kg)</th>
<th>Body fat ratio (%)</th>
<th>Edema ratio</th>
<th>Systolic BP (mmHg)</th>
<th>Diastolic BP (mmHg)</th>
<th>Daytime UF (times)</th>
<th>Nocturnal UF (times)</th>
<th>QOL score (points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>63.5 ( \pm ) 5.7</td>
<td>26.2 ( \pm ) 4.9</td>
<td>0.357 ( \pm ) 0.009</td>
<td>141 ( \pm ) 10</td>
<td>88 ( \pm ) 9</td>
<td>9.1 ( \pm ) 1.4</td>
<td>3.3 ( \pm ) 0.7</td>
<td>4.4 ( \pm ) 0.7</td>
</tr>
<tr>
<td>After</td>
<td>62.7 ( \pm ) 5.3</td>
<td>25.1 ( \pm ) 4.6</td>
<td>0.350 ( \pm ) 0.007</td>
<td>134 ( \pm ) 6</td>
<td>84 ( \pm ) 5</td>
<td>8.4 ( \pm ) 1.2</td>
<td>1.9 ( \pm ) 0.8</td>
<td>2.2 ( \pm ) 1.1</td>
</tr>
<tr>
<td>P value</td>
<td>(&lt; 0.001)</td>
<td>(&lt; 0.001)</td>
<td>(&lt; 0.001)</td>
<td>(&lt; 0.001)</td>
<td>(&lt; 0.001)</td>
<td>(&lt; 0.001)</td>
<td>(&lt; 0.001)</td>
<td>(&lt; 0.001)</td>
</tr>
</tbody>
</table>
Effects of walking exercise on nocturia in the elderly

0.009 to 0.350 ± 0.007, so that it returned to within the normal range (0.300–0.350).

Among the biochemical parameters (Table 2, Fig. 1), serum levels of AD (normal range: < 100 pg/mL), NA (normal range: 100–450 pg/mL), and DP (normal range: < 20 pg/mL) were significantly (all p < 0.001) decreased after 8 weeks of exercise. The parameters of renal function (BUN and CRE) and hepatic function (ALT, ALP, LDH, and ChE) including TP and ALB were significantly decreased, but the values were all within the normal range both before and after 8 weeks of exercise. TG (normal range: 50–149 mg/dL) and T-Chol (normal range: 150–219 mg/dL) were also significantly (p = 0.014 and p = 0.007, respectively) decreased. Serum BNP was slightly elevated before the start of exercise, but there were not significant changes in serum HANP (normal range < 40 pg/mL) and BNP (normal range < 20 pg/mL) before and after 8 weeks of exercise. None of the urinalysis parameters showed any changes after 8 weeks of exercise.

One patient (67 years old) was diagnosed as having angina and was treated with a vasodilator because he developed chest pain after one month of walking exercise. He had walked for about 2 h every night, but he reduced the exercise time to 30 min after the diagnosis of angina, and had no further chest pain. Nocturia decreased from 3 times to once per night even after the diagnosis of angina.

With regard to the patient’s impressions, 20 patients (67%) felt that their sleep had become deeper and 8 of these 20 patients felt that they had lost weight. Thirteen patients felt that their general condition had improved. The QOL scores of all patients ranged from 4 to 6 points before exercise, so defined a score of 0–1 points after exercise as excellent, 2 points as good, 3 points as fair, and 4 or 5 points as no change. According to these criteria, 8 patients (27%) had an excellent outcome, 10 patients (33%) had a good result, 8 patients (27%) had a fair outcome, and 4 patients (13%) showed no change. Excellent or good results were obtained in 18 patients (60%).

DISCUSSION

The present study showed that walking exercise was effective for the improvement of nocturia in the elderly. The daytime urinary frequency, systolic and diastolic blood pressures, body weight, body fat ra-

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**Table 2. Blood biochemistry examination before and after walking exercise**

<table>
<thead>
<tr>
<th></th>
<th>HANP pg/mL</th>
<th>BNP pg/mL</th>
<th>AD pg/mL</th>
<th>NA pg/mL</th>
<th>DP pg/mL</th>
<th>TP g/dL</th>
<th>ALB g/dL</th>
<th>BUN mg/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>29 ± 16</td>
<td>34 ± 18</td>
<td>53 ± 25</td>
<td>753 ± 135</td>
<td>25 ± 7</td>
<td>7.3 ± 0.2</td>
<td>4.4 ± 0.1</td>
<td>14 ± 3</td>
</tr>
<tr>
<td>After</td>
<td>28 ± 13</td>
<td>30 ± 14</td>
<td>45 ± 29</td>
<td>635 ± 143</td>
<td>16 ± 5</td>
<td>7.2 ± 0.3</td>
<td>4.3 ± 0.2</td>
<td>11 ± 2</td>
</tr>
<tr>
<td>P value</td>
<td>0.065</td>
<td>0.055</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.029</td>
<td>&lt; 0.042</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>CRE mg/dL</th>
<th>AST IU/L</th>
<th>ALT IU/L</th>
<th>ALP IU/L</th>
<th>LDH IU/L</th>
<th>ChE IU/L</th>
<th>TG mg/dL</th>
<th>T-Chol mg/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>0.85 ± 0.10</td>
<td>20 ± 5</td>
<td>20 ± 9</td>
<td>116 ± 11</td>
<td>340 ± 36</td>
<td>326 ± 25</td>
<td>199 ± 71</td>
<td>226 ± 17</td>
</tr>
<tr>
<td>After</td>
<td>0.83 ± 0.15</td>
<td>20 ± 7</td>
<td>18 ± 10</td>
<td>107 ± 13</td>
<td>321 ± 20</td>
<td>309 ± 25</td>
<td>169 ± 132</td>
<td>209 ± 20</td>
</tr>
<tr>
<td>P value</td>
<td>0.041</td>
<td>0.365</td>
<td>0.011</td>
<td>&lt; 0.001</td>
<td>0.003</td>
<td>&lt; 0.001</td>
<td>0.014</td>
<td>0.007</td>
</tr>
</tbody>
</table>

**Fig. 1** Change rate of blood biochemistry examination after walking exercise. Serum catecholamine level (AD, NA, DP), parameters of renal function (BUN and CRE) and hepatic function (ALT, ALP, LDH, and ChE) including TP and ALB, TG, and T-Chol were decreased after 8 weeks of exercise. There were not significant changes in serum HANP, BNP, and AST after 8 weeks of exercise. *: p < 0.05, **: p < 0.01, ***: p < 0.001
tio, edema ratio, serum catecholamines, triglycerides, and total cholesterol were also decreased by exercise, suggesting that walking exercise could have an additional preventive effect on lifestyle-related diseases.

Elderly patients with nocturia have been reported to have high levels of HANP and/or BNP (19, 22). However, in the present study, the baseline level of HANP before exercise was within the normal range although its level was slightly decreased after exercise. Therefore, it might be one of the reasons why there was no significant difference in serum HANP level after exercise. On the other hand, the edema ratio was slightly, but significantly, decreased after exercise. Therefore, the edema ratio may reflect the amount of surplus water in the body more sensitively rather than HANP or BNP. However, it is unlikely that walking exercise decreased nocturia mainly by an influence on the edema ratio, because the change of this ratio was very small. On assessment of the patient’s impressions, 67% of the patients felt that their sleep became deeper. Therefore, it is possible that the exercise tired the patients and made their sleep deeper. It has been reported that deeper sleep raises the arousal threshold and may increase the bladder capacity during sleep (9, 21). That is, the improvement of nocturia by exercise is thought to be due to the induction of deeper sleep by walking in the evening or at night, which is the same mechanism as that of hypnotic therapy for nocturia. Our previous study showed that the serum melatonin level was extremely lower in elderly persons with nocturia over 2 times per night compared to the levels in elderly or younger persons without nocturia (19). Melatonin is produced by the pineal gland and is one of the strongest natural antioxidants as well as having a close relation to the timing of sleep in humans. Therefore, sleep disorder may exist in elderly persons with nocturia. Administration of melatonin before sleeping has been reported to be effective for nocturia (8), and melatonin secretion is increased by correcting the daily lifestyle rhythm (4). Therefore, if a person can perform walking exercise, it seems that such exercise can improve nocturia in a natural manner and can also contribute to the prevention of lifestyle-related diseases.

According to our previous study, an increase of serum catecholamine levels was one of the characteristics of elderly persons with nocturia (19). Recently, it has been suggested that the occurrence of nocturia can be attributed to nocturnal polyuria and/or diminished nocturnal bladder capacity (11, 23), and this has been widely accepted. It has been reported that the prevalence of nocturia is 68% for both men and women with hypertension (13), and that the mean blood pressure is higher in men with nocturnal polyuria than in controls (6, 14). Therefore, hypertension may be one factor contributing to the occurrence of nocturnal polyuria. Hypertension caused by an increase of daytime catecholamine levels would increase renal arterial resistance and decrease renal blood flow, thus leading to insufficient daytime urine production (6, 13). In the present study, the daytime plasma catecholamine levels of our patients were high. Therefore, daytime urine production might not have been adequate in our elderly nocturia patients with high catecholamine levels even if they had a high fluid intake. Plasma catecholamine levels are known to fall at night due to circadian rhythm and a nocturnal decrease of catecholamine levels would lower renal arterial resistance and allow renal blood flow to increase, thus increasing urine production to excrete water stored during the daytime. Conversely, an exercise-related decrease of catecholamine levels in the daytime would reduce body water stores and could be effective for reducing urine production at night.

It is also possible that an increase of plasma catecholamine levels is not only related to nocturnal polyuria but also to diminished nocturnal bladder capacity. Intrathecal injection of an adrenergic alpha-1 receptor antagonist inhibits isovolumetric bladder contraction without affecting the bladder contraction pressure in rats (20). This result suggests that an increase of plasma catecholamine levels may influence the ascending limb of the micturition reflex in the spinal cord and induce the urge to urinate at smaller bladder volumes, a phenomenon similar to the urinary urge associated with stress. Indeed, administration of an adrenergic alpha-1 receptor antagonist before sleeping to patients with morning hypertension has been shown to decrease nocturnal urination (18). Therefore, it is possible that the decrease of catecholamine levels associated with walking exercise was also effective for nocturia by increasing the threshold bladder capacity that induced awakening.

In the present study, one patient developed angina after performing walking exercise for 2 h per day. Therefore, too much exercise must be avoided. Exercise therapy is a treatment for comparatively healthy persons with adequate physical strength and energy. However, simple walking exercise may prevent a bedridden state, and such exercise was shown to improve nocturia, daytime frequency, systolic and...
diastolic blood pressures, body weight, body fat ratio, edema ratio, serum catecholamines, TG, and T-Chol in this study. Weight loss may have led to the decrease of some parameters: renal function (BUN and CRE) and hepatic function (ALT, ALP, LDH, ChE) including TP and ALB. However, these values were within the normal range both before and after walking exercise, which seems to promote general health.

In conclusion, we investigated whether nocturia in the elderly was improved by walking exercise for 8 weeks. Episodes of nocturia were significantly decreased after walking exercise. In addition, daytime urinary frequency, blood pressure, body weight, body fat ratio, edema ratio, serum catecholamines, TG, and T-Chol were all significantly decreased. Assessment of patient’s impressions revealed that their sleep became deeper after exercise. Therefore, the main factor related to the influence of walking exercise on nocturia was that sleep became deeper, which increased the arousal threshold bladder volume. Walking exercise may also have a preventive effect on lifestyle-related diseases.

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