ORIGINAL RESEARCH

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Evaluation of sleeping energy expenditure using the SenseWear Armband in patients with overt and subclinical hypothyroidism

Abstract

Purpose: The aim of the present study was to evaluate the average sleeping energy expenditure (EE) levels using the SenseWear Armband (SWA) in patients with overt and subclinical hypothyroidism.

Methods: Sixty patients with hypothyroidism and 30 healthy individuals were recruited for the study. Hypothyroid patients were divided into two groups: group 1 (n = 30) consisted of patients with overt hypothyroidism and group 2 (n = 30) consisted of patients with subclinical hypothyroidism. Lastly, group 3 (n = 30) consisted of healthy subjects. The average EE and metabolic equivalent of task (MET) values during sleep of all the hypothyroid participants were analyzed at baseline and at the end of the study. Data were also obtained from the healthy subjects at baseline.

Results: The average sleeping EE and METs values were not significantly different at baseline. Similarly, these values did not change significantly after achieving a euthyroid state via thyroid hormone replacement (both $p > 0.05$).

Conclusions: Contrary to what has been previously reported, the average sleeping EE and METs values in all hypothyroid patients and healthy individuals were similar at baseline and did not change in the patients with overt and subclinical hypothyroidism after achievement of a euthyroid state.

Manuscript submitted 12th January, 2012
Manuscript accepted 26th March, 2012

Clin Invest Med 2012; 35 (3): E126-E131.

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Hypothyroidism is a relatively common problem worldwide. It often has an insidious onset and is relatively asymptomatic. It occurs in two forms: overt and subclinical. Overt hypothyroidism is characterized by a marked elevation of the thyroid-stimulating hormone (TSH) level with decreased levels of free thyroxine (fT4) and free triiodothyronine (fT3), whereas subclinical hypothyroidism (sHT) is defined as having serum fT4 levels within the normal range and elevated supra normal serum TSH levels [1-3]. Thyroid activity is related to energy expenditure (EE), and increased thyroid activity is able to increase basal metabolism. Consequently, decreased thyroid activity reduces basal metabolism and usually presents as an increase in body weight [4, 5].

Human 24 h energy expenditure has three major components: the resting EE, the thermic effect of food, and the energy cost of physical activity [6]. The basal metabolic rate is difficult to measure in most situations, except perhaps during sleep, because EE increases above basal levels as a result of the energy cost of arousal [2]. The SenseWear Pro Armband (SWA) is a recently developed portable device used to assess EE. It is worn on the upper arm (usually the dominant side) over the triceps muscle, and it monitors various physiological and movement parameters. The SWA also provides estimates of the intensity, frequency and duration of a physical activity [7, 8]. The metabolic equivalent of task (MET) represents the intensity of energy cost of physical activities as multiples of the resting metabolic rate. The SWA device has been validated in free-living adults, children and clinical patients [9-15]. Additionally, previous studies have reported that the SWA is highly reliable at estimating the EE at rest [7, 13, 16, 17].

Although the SWA device has been used and validated in the various situations mentioned above, there have been no clinical research studies to demonstrate the feasibility of the SWA to measure and monitor EE in patients with hypothyroidism. Because the daily EE level varies from person to person, the aim of the present study was to evaluate the average sleeping EE levels using the SWA device in patients with overt and subclinical hypothyroidism.

Materials and Methods

Study design and patients

This prospective study was conducted at the Harran University School of Medicine, Sanliurfa, Turkey. Prior to subject recruitment, the study protocol was reviewed and approved by the local ethics committee, in accordance with the ethical principles for human investigations, as outlined by the Second Declaration of Helsinki, and written informed consent was ob-

tained from all the patients. From January-2011 to October-2011, 30 patients with overt hypothyroidism, 30 patients with sHT and 30 age- and gender-matched healthy volunteers were recruited to the study.

Hypothyroid patients were divided into two groups: group 1 (n = 30) consisted of patients with overt hypothyroidism and group 2 (n = 30) consisted of patients with sHT. Finally, group 3 (n = 30) consisted of healthy subjects. The exclusion criteria were as follows: recent acute infectious illness; any inflammatory or infiltrative disorder; any evidence of liver, kidney, or respiratory disease; diabetes mellitus; malignancy; use of any systemic drug that might have affected the SWA or the thermoregulatory process and would affect their bodyweight or metabolism; regular alcohol use; smokers; pregnancy; depression; sleep disorders; and psychiatric or neurological disorders. None of the patients had problems with adaptation to the devices used for assessment. The average EE and METs values during sleep of all hypothyroid participants were analyzed at baseline and at the end of the study. Data were also obtained from the healthy subjects at baseline.

Baseline definitions and measurements

Height and weight were measured according to standardized protocols. Body mass index was calculated as the weight in kilograms divided by the height in meters squared (kg/m²). Blood pressure was measured using a mechanical sphygmomanometer in the medical office setting. For each subject, after being seated comfortably for 15 minutes, the average of three blood pressure measurements was calculated. Body compositions were assessed with bioelectrical impedance analysis (BF 510, Omron Healthcare Co. Ltd., Kyoto, Japan).

Biochemical analysis

All of the blood samples were drawn from a large antecubital vein without interruption of the venous flow using a 19-gauge butterfly needle connected to a plastic syringe. Twenty milliliters of blood was drawn, with the first few milliliters discarded. Ten milliliters of blood was used for baseline routine laboratory tests. TSH, fT3 and fT4 levels were analyzed using an electrochemiluminescence immunometric assay (ECLIA) method with a Roche Elecsys E170 immuno-analyzer (Roche Diagnostics, Burgess Hill, UK). Serum urea, creatinine, fasting blood glucose, aspartate aminotransferase, alanine aminotransferase, triglycerides, total cholesterol, and high-density and low-density lipoprotein cholesterol levels were determined using commercially available assay kits (Abbott, Abbott Park, USA) with an auto-analyzer (Abbott, Abbott Park, USA).

Analyzing sleeping energy expenditure and MET values with the SWA

For this study, the manufacturer provided the most recent version of the SenseWear Pro Armband™ Version 6.1 (Body Media, Pittsburgh, USA). It is a portable device that is 8.8 x 5.6 x 2.1 cm in size and 82 g in weight. The SWA utilizes a multi-sensor array that includes a 2-axis accelerometer, a heat flux sensor, a galvanic skin response sensor, a skin temperature sensor, and a near-body ambient temperature sensor. The SWA was placed on the dominant arm over the triceps muscle at the midpoint between the acromion and olecranon processes. The subject's gender, age, height, and weight were programmed into the SWA. The average EE and METs values during sleep were analyzed with InnerView Research Software (version 6.1) provided by BodyMedia, Inc. The METs values define the EE related to the body weight. One MET is equivalent to a metabolic rate consuming 1 kilocalorie per kilogram of body weight per hour (1 kcal/kg body weight/hour) [18].

Statistical analysis

All statistical analyses were performed using SPSS 17.0 for Windows (SPSS, Chicago, IL, USA). Kolmogorov-Smirnov tests were used to test the normality of the data distribution. The data are expressed as the mean and standard deviation. The chi-square test was used to compare the categorical variables between groups. One-way ANOVA with a post hoc Bonferroni and Kruskal Wallis tests were used for normally and non-normally distributed continuous data, respectively. Paired t-test and Wilcoxon signed-rank tests were used to analyze changes within the hypothyroid patients. A two-sided p value < 0.05 was considered to be statistically significant.

Results

The clinical, biochemical and demographic characteristics of the study groups are presented on Table 1. There were no significant differences in gender, age, body mass index and body compositions between the control and hypothyroid groups (p > 0.05 for all). The average sleeping EE and METs values were not significantly different at baseline and did not change sig-

FIGURE 1. Baseline and post-treatment average sleeping energy expenditure and MET values

A) Average sleeping energy expenditure (cal/hour) at baseline in subjects with overt hypothyroidism (Group 1), subclinical hypothyroidism (Group 2) and healthy subjects (Group 3), B) Post-treatment average sleeping energy expenditure (cal/hour), C) MET values at baseline, D) Post-treatment MET values

Table 1: Baseline comparison of the demographic, laboratory and clinical characteristics of all subjects

	Group 1 (n=30)	Group 2 (n=30)	Group 3 (n=30)	p
Gender, male/female	11/19	10/20	12/18	NS ^a
Age, years	38.13±9.33	37.30±9.37	35.10±9.02	NS ^b
BMI, kg/m ²	26.96±3.05	27.80±3.91	26.24±3.55	NS ^b
Body fat, %	30.37±8.92	31.52±7.84	29.53±9.47	NS ^b
Visceral fat percentage, %	10.55±3.19	11.02±2.99	10.15±3.28	NS ^b
Lean body mass percentage, %	25.51±6.33	26.71±5.82	26.19±6.35	NS ^b
Systolic BP, mmHg	108.12±9.42	114.00±8.34	109.66±7.56	NS ^b
Diastolic BP, mmHg	72.23±7.82	71.15±8.39	69.85±6.96	NS ^b
FBG, mg/dL	91.23±11.00	90.93±9.12	92.10±9.82	NS ^b
Urea, mg/dL	32.41±6.65	30.94±5.34	29.56±4.91	NS ^b
Creatinine, mg/dL	0.72±0.17	0.68±0.10	0.67±0.11	NS ^c
ALT, U/mL	21.56±15.97	21.00±16.08	17.10±8.13	NS ^c
AST, U/mL	20.23±8.24	19.90±7.61	16.83±4.57	NS ^b
Total cholesterol, mg/dL	214.80±49.20	202.50±49.20	173.21±39.26	<0.05 ^b
Triglyceride, mg/dL	153.63±73.03	159.43±9.17	142.56±66.67	NS ^b
LDL, mg/dL	132.29±40.46	133.40±34.10	106.06±40.86	<0.05 ^b
HDL, mg/dL	44.12±9.65	47.54±8.43	45.91±6.88	NS ^a
TSH, µIU/L	30.05±13.67	6.88±1.30	2.07±0.86	<0.05 ^b
fT3, pg/mL	1.85±0.67	2.82±0.26	2.85±0.36	<0.05 ^b
fT4, ng/dL	0.50±0.23	1.23±0.20	1.24±0.18	<0.05 ^b
ASEE, cal/hour	76.13±11.31	74.76±9.63	74.03±6.40	NS ^b
METs	0.91±0.10	0.87±0.07	0.86±0.08	NS ^c

All measurable values are given as the mean ± standard deviation. NS: not significant, BMI: body mass index, BP: blood pressure, FBG: fasting blood glucose, ALT: alanine aminotransferase, AST: aspartate aminotransferase, LDL: low density lipoprotein, HDL: high density lipoprotein, TSH: Thyroid stimulating hormone, fT3: free triiodothyronine, fT4: free tetraiodothyronine, ASEE: average sleeping energy expenditure, METs: metabolic equivalent of task

Chi-square^a, one-way ANOVA with a post hoc Bonferroni^b and Kruskal Wallis^c tests were used

nificantly after achievement of the euthyroid state (both $p > 0.05$) (Figure 1).

Conclusion

This is the first published report that evaluates the average sleeping EE using the SWA device in patients with hypothyroidism. Contrary to what has been previously reported [19, 20] the main findings of the present study showed that (i) the average sleeping EE and METs values between hypothyroid patients and healthy individuals were similar at baseline and (ii) after achievement of the euthyroid state, the average sleeping EE and METs values did not change in the patients with hypothyroidism.

There is considerable interest in the habitual physical activity levels and total EE of contemporary humans given the burden of inactivity-related disorders (e.g., cardiovascular disease, obesity, hypertension, type 2 diabetes and hyperlipidemia). Therefore, a need for nonintrusive, accurate and valid methods for the measurement of physical activity and prediction of EE is warranted to address important health issues [12, 21]. The doubly-labeled water method, indirect calorimetry and metabolic carts are considered to be the gold standard techniques for EE assessment [22, 23]; however, these techniques cannot easily assess free-living subjects in everyday life because of their methodological complexity, limited practicality and/or high cost [24].

Table 2: Baseline and post treatment comparisons of hypothyroid patients

	Group 1			Group 2		
	Baseline	Post treatment	p	Baseline	Post treatment	p
TSH, μ IU/L	30.05 $\pm$ 13.67	2.55 $\pm$ 1.08	<0.05 ^a	6.88 $\pm$ 1.30	2.43 $\pm$ 0.90	<0.05 ^a
fT3, pg/mL	1.85 $\pm$ 0.67	3.25 $\pm$ 0.33	<0.05 ^a	2.82 $\pm$ 0.26	2.91 $\pm$ 0.21	NS ^a
fT4, ng/dL	0.50 $\pm$ 0.23	1.40 $\pm$ 0.17	<0.05 ^a	1.23 $\pm$ 0.20	1.22 $\pm$ 0.18	NS ^a
ASEE, cal/hour	76.13 $\pm$ 11.31	76.20 $\pm$ 10.05	NS ^a	74.76 $\pm$ 9.63	75.03 $\pm$ 7.35	NS ^a
METs	0.91 $\pm$ 0.10	0.90 $\pm$ 0.10	NS ^b	0.87 $\pm$ 0.07	0.87 $\pm$ 0.07	NS ^b

All measurable values are given as the mean $\pm$ standard deviation. NS: not significant, TSH: Thyroid stimulating hormone, fT3: free triiodothyronine, fT4: free tetraiodothyronine, ASEE: average sleeping energy expenditure, METs: metabolic equivalent of task. Paired sample T^a and Wilcoxon signed-rank^b tests were used.

The SWA is a valid, reliable, portable, practical and easily accessible device that reports total and active EE, METs values, duration and quantification of physical activity, body position, sleep efficiency, and sleep duration. Furthermore, the SWA relies more on subject characteristics, such as age, gender and weight, to calculate the resting metabolic rate, and it is not sensitive to small changes in EE from day to day [13, 25]. Modulation of the resting EE by thyroid hormones is well recognized in humans and rodents [2, 26]. In vivo assessment of the effects of thyroid hormones on total EE is not easy. Because of the difficulty in reaching the basal metabolic rate under most measurement situations, the resting metabolic rate is frequently determined using the same measurement conditions stated for determining the basal metabolic rate. For these reasons, we used SWA devices and chose the sleeping time to determine the metabolic activities of the subjects in our study.

It has been known for over a century that thyroid hormones stimulate the rate of metabolism and is a primary regulator of energy homeostasis in both energy intake and expenditure. It has also been known for many years that the resting EE is highly responsive to thyroid hormones. Furthermore, it is known that increased thyroid activity accompanies increased basal metabolism or vice versa: many thyrotoxic patients show increased physical activity and, conversely, many hypothyroid patients complain of lethargy. The mechanisms through which the thyroid hormone is related to the alterations in energy homeostasis and leads to changes in metabolism and molecular pathways have not been clearly identified and remain incompletely understood [4, 26-29]. In this study, we did not detect a difference in energy expenditure between patients with hypothyroidism and healthy subjects. Furthermore, treatment of the hypothyroidism did not change the metabolic rate of the patients after achieving a euthyroid state.

Conclusion

To our knowledge, the effects of thyroid hormones and the different states of thyroid disease on distinct components of EE have not been studied before. Our findings may add data to the information that is lacking in this field. Although it has been known for over a century that the metabolic rate is decreased in hypothyroidism, the mechanism of this effect is not clearly described and remains controversial. Although the reliability and validity of the SWA device, which was used in the present study, has been demonstrated, the present results should be interpreted with caution because the sample size is small and our findings require further validation. Therefore, these results should be verified with large-scale, multicenter prospective cohort studies that are conducted using modern technologies and methods.

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