The Changes in the ^{18}F FDG Metabolism in the Muscles by the Use of Cuboid Support Insoles

Abstract

Healthy men aged 55,39, 23.45 years were administered 18F-fluorodeoxyglucose (^{18}F-FDG) after fasting for over 5 h; then, a 30-min self-paced walking (6-min walk and 2-min rest + 6-min walk and 2-min rest + 6-min walk and 2-min rest + 6-min walk) session was performed. While walking, the same athletic shoes were used, same with walking supports, flat insoles, and cuboid support insoles (BMZ Inc., Tokyo, Japan). The walking test was performed with eye open. The examination was performed over 30 days apart. ^{18}F-FDG accumulation within the gastrocnemius muscle was higher, the walking speed was improved. These results suggest that the use of cuboid support insoles may improve the cadence of the lower leg muscles.

Keywords: *18F-fluorodeoxyglucose, insole, muscle*

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Introduction

Positron Emission Tomography (PET) is an imaging method of examination that detects 511 keV annihilation radiation, which is emitted in a nearly orthogonal direction when protons bind electrons to decay, with a coincidence circuit. In recent years, PET combined with computed tomography (CT), PET-CT, has become popular and has been widely used in clinical settings and studies.[1]

In PET, ^{18}F-fluorodeoxyglucose (^{18}F-FDG), which shows similar kinetics to glucose, has been commonly used as a radiotracer. The procedure itself has become more common as nuclear medicine, and PET are covered by insurance for the diagnosis of malignant tumors in Japan. In particular, the usefulness of ^{18}F-FDG for the diagnosis of malignant tumors has been widely reported.[2] ^{18}F-FDG has also been used in the diagnosis of brain diseases, such as dementia.[3] Brain PET imaging has allowed quantitative assessment with a statistical index (Z-score), such as three-dimensional stereotactic surface projection, in addition to visual assessment.[4] Furthermore, the accumulation of ^{18}F-FDG within muscles during exercise has been studied.[5] However, many points regarding gait remain unclear. While insoles are used as a method to stabilize gait, they are kept in currently use despite poor scientific evidence.[6] Many insoles adopt a way to directly push up the medial arch of the foot, whereas the cuboid support insoles manufactured by BMZ Inc. (Minakami, Japan), hereafter referred to as cuboid support insoles, use an approach targeting the lateral arch of the foot. The first author and others have reported enhancement in gait stability by using such insoles.[7,8] However, how the accumulation of ^{18}F-FDG within muscles changes when using these insoles and how the accumulation of ^{18}F-FDG within the brain changes during exercise are not fully understood. Herein, we report on ^{18}F-FDG examination during walking in two subjects.

Case Reports

Four healthy male volunteers with no experience with this specific exercise underwent.

This ^{18}F-FDG examination. Written informed consent was obtained and the approval of the institute (PET Sendai Medical Imaging Clinic) was received.

The subjects were fasted for 5 h before examination. After intravenous injection of approximately 2.6 MBq/kg ^{18}F-FDG prepared at PET Sendai Medical Imaging Clinic by using a hospital cyclotron, they were asked to walk for 30 min and imaging of the head, legs, and trunk was performed

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by using a PET-CT scanner (Biograph, Siemens, Munich, Germany). Walking was set to a 30-min self-paced walking session (6-min walk and 2-min rest + 6-min walk and 2-min rest + 6-min walk and 2-min rest + 6-min walk). The walking test was performed with eye open. When walking, the same athletic shoes were used, as were the walking supports. Flat (regular) insoles were used in the initial examination, then cuboid support insoles (BMZ Inc.). The examination was repeated over 30 days apart. For gait analysis, a wearable acceleration sensor was employed: MG-M1110 (LSI Medience, Tokyo, Japan) was used to calculate the walking rate (cadence), walking distance, walking speed, and walking intensity (average acceleration).

PET-CT examination was performed under the supervision of a co-author (I.M.), who is a board-certified nuclear medicine specialist (Japan Society of Nuclear Medicine) and have enough experience about PET-CT diagnosis.

PET-CT images were visually assessed by a co-author (O.Y.), who is a board-certified radiologist and radiation oncologist (Japan Radiological Society, Japanese Society for Radiation Oncology), board-certified nuclear medicine specialist (Japan Society of Nuclear Medicine, trained PET-CT imaging for short time intensively before at belong hospital with 2 unit PET-CT and have experience in daily practice now)

Case 1 [Figure 1]

A 55-year-old man (author). He is the first author. His past medical history has nothing remarkable. He has no experience with special exercise.

With regard to the exercise, during regular walking, there was an increase in the accumulation of FDG within both the lower legs and femurs similar to the level within the liver. After using the cuboid support insoles, there was an increase in accumulation involving both the femurs similar to the level within the liver, whereas the accumulation within both the gastrocnemius and soleus muscles was higher than that in the liver. In addition, walking speed and cadence increased.

Case 2 [Figure 2]

A 39-year-old man (co-author). He is the third author. His past medical history is also unremarkable. He also has no experience with special exercise.

With regard to the exercise, during regular walking, there was an increase in FDG accumulation within the left gastrocnemius muscle similar to the level within the liver and this accumulation differed between the right and left muscles. After using the cuboid support insoles, the accumulation within both the femurs was lower than that in the liver. The accumulation in the left gastrocnemius muscle was higher than in the liver. In addition, walking speed and cadence increased.

Case 3 [Figure 3]

A 23-year-old man (author). He is the Fourth author. His past medical history has nothing remarkable. He has no experience with special exercise.

With regard to the exercise, during regular walking, there was an increase in the accumulation of FDG within the right lower legs and femurs lower to the level within the liver. After using the cuboid support insoles, the accumulation within both the femurs was lower than that in the liver. Whereas the accumulation within right the gastrocnemius and soleus muscles was higher than that in the liver. In addition, walking speed and cadence increased.

Case 4 [Figure 4]

A 45-year-old man (author). He is the Fifth author. His past medical history has nothing remarkable. He has no experience with special exercise.

With regard to the exercise, during regular walking, there was an increase in the accumulation of FDG within both femurs, both lower legs and femurs higher to the level within the liver. After using the cuboid support insoles, there was a decrease in accumulation involving both the femurs which was lower than that in the liver. Moreover, the gastrocnemius and soleus muscles were higher than that in the liver. In addition, walking speed and cadence increased.

The results are shown in Figure 1 (case 1), Figure 2 (case 2), Figure 3 (case 3), figure 4 (case 4), and Table 1.

Discussion

Humans are walking organisms. A study using ^{15}O-H2O reported an increase in cerebellar blood flow when in a standing position.[9] In addition, another study using ^{15}O-H2O reported increased blood flow within the cerebellum, the frontal lobe, and the right visual cortex.[10] The two subjects in the present study, in which ^{18}F-FDG was used, showed increased accumulation relatively within their occipital lobes and cerebelli when walking, which was similar to those with ^{15}O-H2O.

A study in seven healthy adult men showed an increase in FDG accumulation after exercise within the leg and femoral muscles.[5] A study in 12 healthy adult men, showed an increase in FDG accumulation after exercise within the lower leg muscles and heart.[11] A study in 17 healthy adult men showed a larger increase in FDG accumulation within the muscles of the lower leg than in the muscles of the crus during exercise.[12] A study in 31 healthy adult men, in cases when running loaded, there was increased FDG accumulation within the tibialis anterior muscle, peroneal muscle, muscles of the posterior cervical vertebrae/axilla, extensor digitorum longus muscle, soleus muscle, gastrocnemius muscle, extensor muscles of the lower leg, flexor muscles of the lower leg, quadratus femoris muscle, flexor digitorum brevis muscle, and abductor digiti minimi muscle when compared with resting.[13] Thus, the

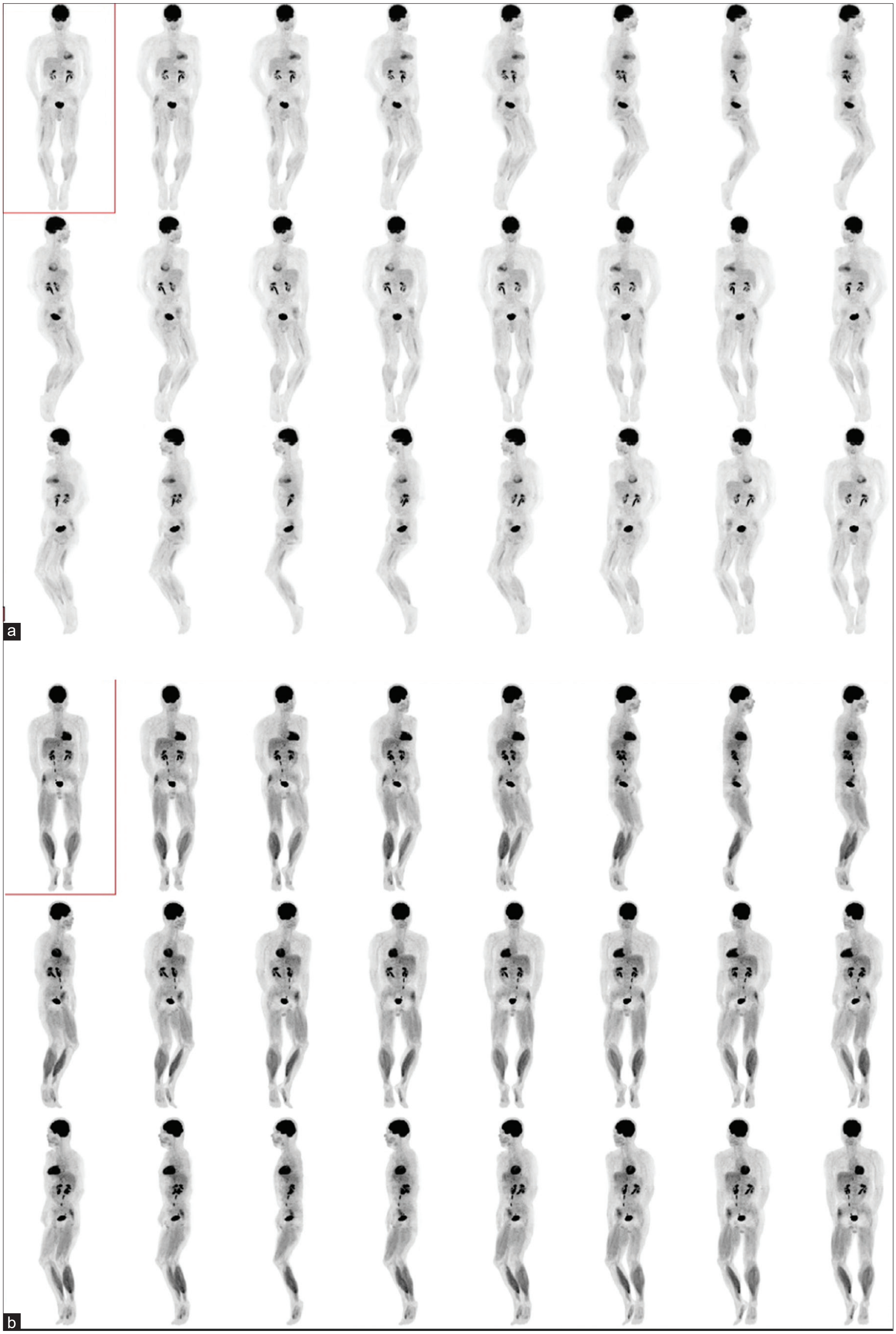

Figure 1: (a) PET scan images of the brain and whole body in subject 1 when using the flat (regular) insoles. (b) PET scan images of the brain and whole body in subject 1 when using the cuboid support (BMZ) insoles

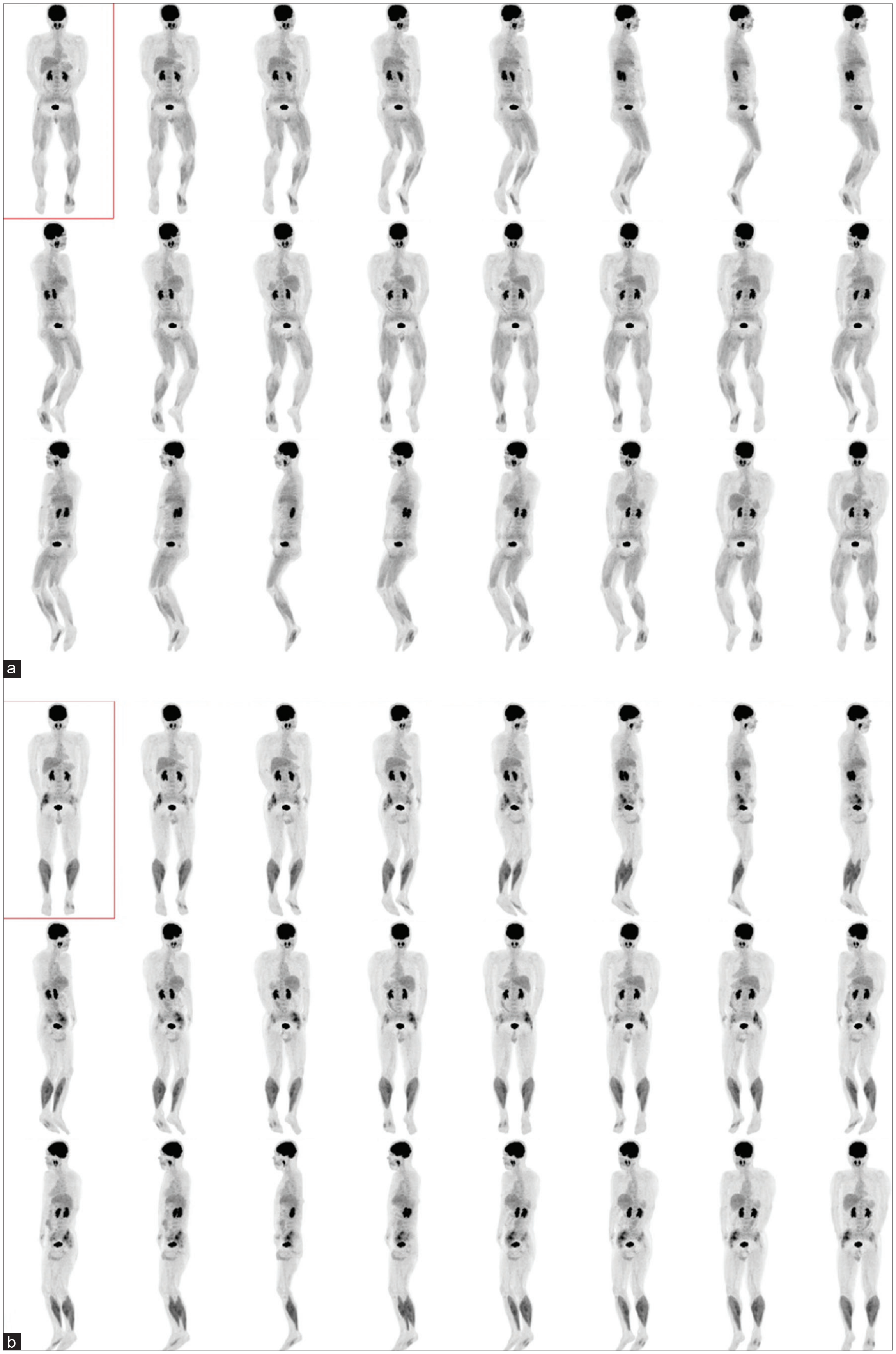

Figure 2: (a) PET scan images of the brain and whole body in subject 2 when using the flat (regular) insoles. (b) PET scan images of the brain and whole body in subject 2 when using the cuboid support (BMZ) insoles

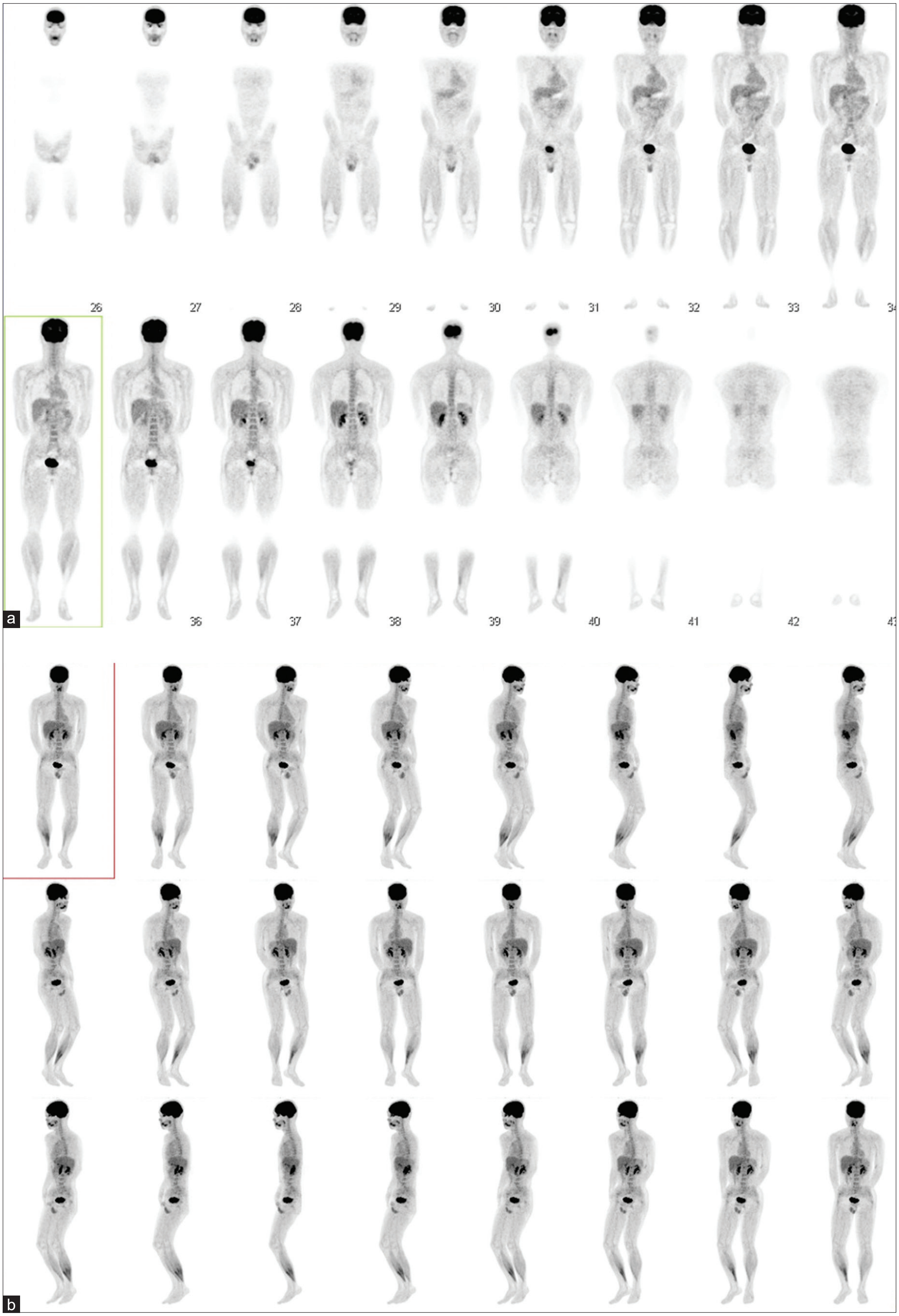

Figure 3: (a) PET scan images of the brain and whole body in subject 3 when using the flat (regular) insoles. (b) PET scan images of the brain and whole body in subject 3 when using the cuboid support (BMZ) insoles

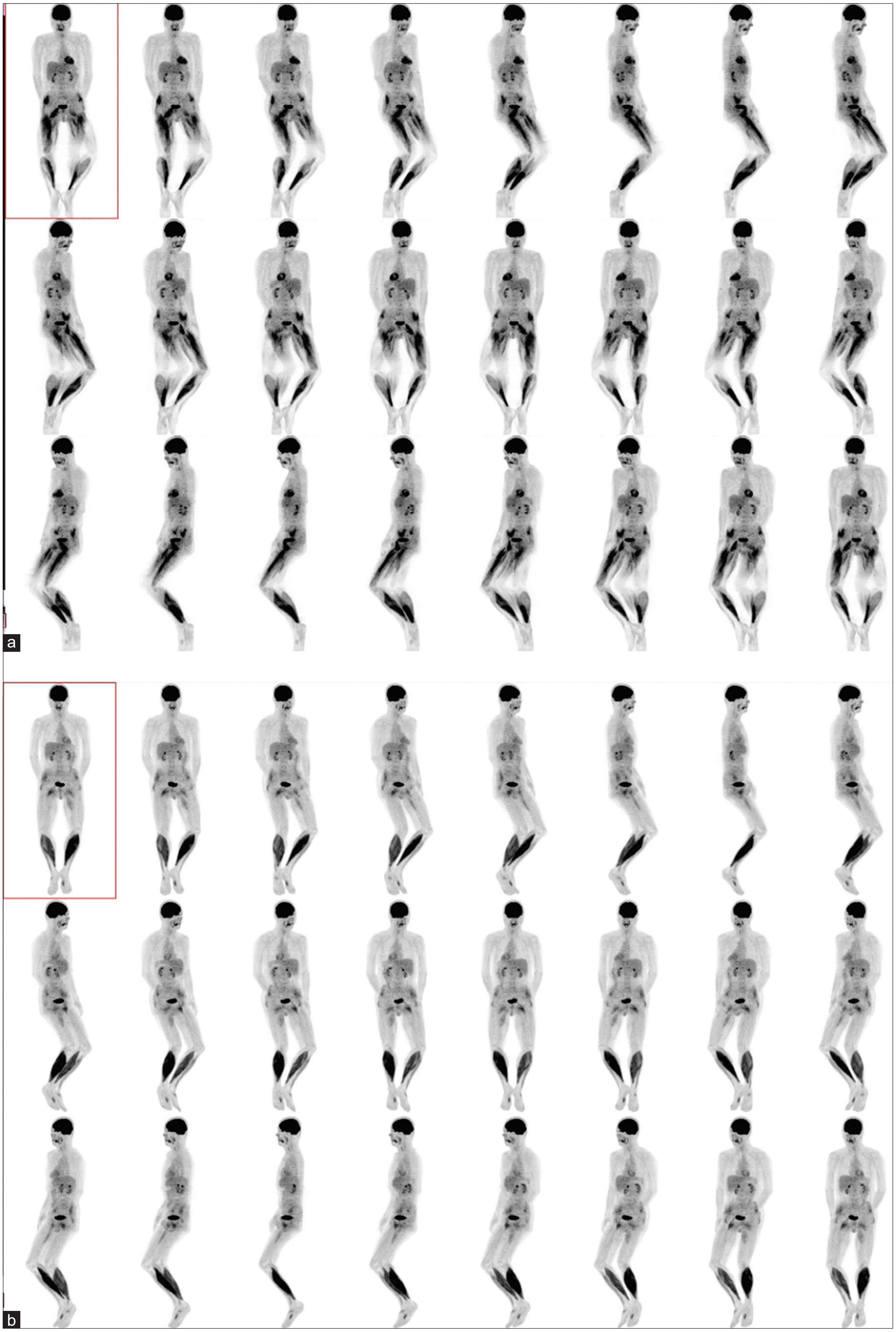

Figure 4: (a) PET scan images of the brain and whole body in subject 4 when using the flat (regular) insoles. (b) PET scan images of the brain and whole body in subject 4 when using the cuboid support (BMZ) insoles

Table 1: Comparison between subjects 1 and 2

	Subject 1	Subject 2	Subject 3	Subject 4
Age (years)	55	39	23	45
Flat(Regular) insoles	Accumulation in both the lower legs/femurs similar to the level in the liver	Accumulation in the left gastrocnemius muscle similar to the level in the liver	Accumulation in both lower legs/femurs inferior the level in the liver	Accumulation in both lower legs/ femurs higher the level in the liver
Cuboid support (BMZ)	Accumulation in the liver <both gastrocnemius muscles/soleus muscles <the brain	Accumulation in the liver <the left gastrocnemius muscle <the brain	Accumulation right gastrocnemius muscles/ soleus muscles <in the liver <the brain	Accumulation in the liver <both gastrocnemius muscle <the brain
Accumulation in the femur	Similar to the level in the liver with the BMZ insoles	Lower than the level in the liver with the BMZ insoles	Lower than the level in the liver with the BMZ insoles	Lower than the level in the liver with the BMZ insoles
Without the cuboid support (BMZ) insoles				
Cadence (steps/min)	95.38	92.74	84.43	110.73
Walking Distance M	1487.89	1446.80	1317.11	1860.31
Walking speed m/min	62	60.28	54.88	77.51
Walking intensity (G)	0.19	0.16	0.19	0.29
With the cuboid support (BMZ) insoles				
Cadence (steps/min)	109.27	97.31	99.50	108.56
Walking Distance m	1756.98	1541.39	1576.16	1849.82
Walking speed m/min	73.21	64.22	65.67	77.08
Walking intensity (G)	0.28	0.17	0.25	0.24

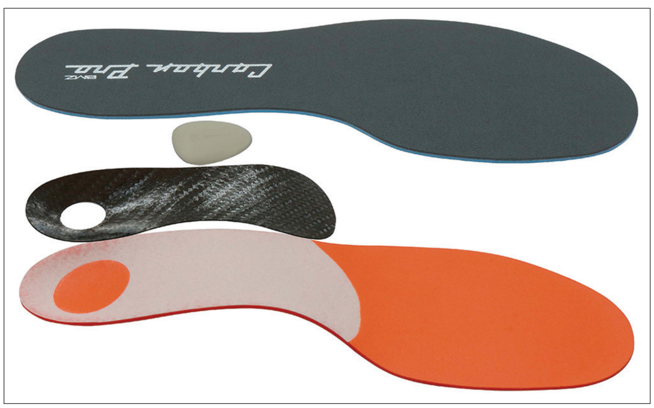

Figure 5: The insole was shown for reference (provided by BMZ Inc.)

accumulation in the muscles of the lower leg is considered to increase during appropriate exercise.

In the presented four subjects, we compared PET-CT changed when flat insoles versus cuboid support insoles were used [Figure 5]. Accumulation of ^{18}F-FDG within the femur did not change or slightly decreased when using cuboid insoles, whereas accumulation increased within the muscles of the lower leg and walking speed improved. Thus, these results suggest that switching insoles may be enough to alter gait. When gait is assessed in routine medical care, types of insoles need to be carefully considered.

In this case reports, there are some limitations. First the case number was small. So statically evaluation was difficult. In this case reports, there are some limitations. First the case number was small. So statically evaluation was difficult. In this case reports, we think that statistically evaluation is difficult as the sample size was small and we used visual evaluation. Third, the configuration of control is insufficient as numb More research is necessary. We think prospective study is necessary.

The sample size was small and we used visual evaluation. In other study, SUR (standard uptake ratio) = mean region of interest count (cps/pixel)/body weight (g) injected dose (mCi) × calibration factor (cps/mCi) was used as the semi-quantitative parameter.[5,13] The configuration of the region of interest depends on the reader, but this semi-quantitative parameter may be useful. Second, the explanation of asymmetrical acculturation in the foot is not enough. We think this asymmetrical acculturation is based on the habit of walking, but more research in important. Third, the configuration of control is insufficient as numb More research is necessary. We think prospective study is necessary.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

The research fund has been provided by BMZ Inc. However, we had the Tohoku University ethics committee and Miyagi Prefectural Government verify and this study has been judged not applicable to the specified clinical study.

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