國立成功大學 107 學年度碩士班招生考試試題

※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

There are two parts in this exam. PART I is on page one and PART II is on page four. Please read the questions carefully and answer them.

PART I. Please answer the following questions according to the original article entitled "Effects of weight-bearing exercise on a mini-trampoline on foot mobility, plantar pressure and sensation of diabetic neuropathic feet: a preliminary study". (from *Diabet Foot Ankle. 2017; 8(1): 1287239.*)
For answering the questions, it may not be necessary to read the whole article.

1. How is the research plan developed within a reasonable theoretical framework? （35%）
2. What are the significant contributions of this investigation to add knowledge about this special area? （15%）

摘錄自 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5345576/

Effects of weight-bearing exercise on a mini-trampoline on foot mobility, plantar pressure and sensation of diabetic neuropathic feet; a preliminary study

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ABSTRACT

Objective: Foot and ankle exercise has been advocated as a preventative approach in reducing the risk of foot ulceration. However, knowledge about the appropriate types and intensity of exercise program for diabetic foot ulcer prevention is still limited. The current study aimed to examine the effects of an eight-week mini-trampoline exercise on improving foot mobility, plantar pressure and sensation of diabetic neuropathic feet.

Methods: Twenty-one people with diabetic peripheral neuropathy who had impaired sensation perception were divided into two groups. The exercise group received a foot-care education program plus an eight-week home exercise program using the mini-trampoline ($n = 11$); whereas a control group received a foot-care education only ($n = 10$). Measurements were undertaken at the beginning, at the completion of the eight-week program and at a 20-week follow-up.

Results: Both groups were similar prior to the study. Subjects in the exercise group significantly increased the range of the first metatarsophalangeal joint in flexion (left: $p = 0.040$, right: $p = 0.012$) and extension (left: $p = 0.013$) of both feet more than controlled subjects. There was a trend for peak plantar pressure at the medial forefoot to decrease in the exercise group ($p = 0.016$), but not in the control group. At week 20, the number of subjects in the exercise group who improved their vibration perception in their feet notably increased when compared to the control group (left: $p = 0.043$; right: $p = 0.004$).

Conclusions: This is a preliminary study to document the improvements in foot mobility, plantar pressure and sensation following weight-bearing exercise on a flexible surface in people with diabetic neuropathic feet. Mini-trampoline exercise may be used as an adjunct to other interventions to reduce risk of foot ulceration. A larger sample size is needed to verify these findings. This trial is registered with COA No. 097.2/55.

KEYWORDS: Diabetes, neuropathy, foot mobility, plantar pressure, sensation, foot ulcer

Introduction

Diabetes mellitus is a non-communicable disease which is a national and global public health problem. It is estimated that over 360 million people worldwide will have the disease by year 2030.[1] In developing countries, the prevalence of diabetes has been increasing steadily. A survey of the number of people with diabetes in Thailand in 2003 found that approximately 2.4 million people were living with diabetes and about half of them did not know that they had the disease.[2] Diabetes mellitus leads to many complications. A common complication of diabetes is diabetic peripheral neuropathy (DPN). The symptoms of DPN vary; however, loss of sensation in one or both feet is often an initial sign. Therefore, people with diabetic peripheral neuropathy are inclined to have foot ulcers and are at high risk of foot or leg amputation.[3] Additionally, other causes may lead to foot ulceration such as limited joint mobility and high plantar pressure.[4] Foot ulcer due to diabetes mellitus is a major health problem since it is related to quality of life of the patient and the source of enormous costs to healthcare services.[5,6] The most costly and feared consequence of a foot ulcer is limb amputation,[7,8] which occurs 10 to 30 times more often in people with diabetes than in the general population.[9–11] The estimated cost of treating a diabetic amputee is $34,000 per year.[12] The American Diabetes Association (ADA) has suggested that the best practices in lower limb amputee prevention are reducing risk of foot ulceration and providing appropriate foot care education to patients.[10,13] Moreover, proper foot and ankle exercise has been advocated as another imperative preventative step to reduce the risk of foot ulceration and amputation.[14] Since an increase in weight-bearing activity can lead to higher plantar pressure, resulting in the foot ulceration, the ADA recommends people with DPN to suitably perform the exercise with limited weight-bearing activities.[15–17]

There is limited evidence about the use of exercise programs to decrease the risk of foot ulceration among people with DPN. Previous studies have shown conflicting findings. For example, Flahr [13] applied a non-weight-bearing ankle exercise regimen to people with DPN and foot ulcers and showed that the exercise did not provide better wound reduction than usual care, but could increase joint mobility and improve blood circulation. Goldsmith et al. [18] studied the effect of a home-based active and passive range-of-motion exercise program on joint mobility and plantar pressure for people with diabetes. They found that a range-of-motion exercise program could reduce peak plantar pressure and thus might reduce the risk of foot ulceration.[18] LeMaster et al. [19] studied the effects of an individually adapted weight-bearing exercise program on physical activity and incidence rate of foot lesions among people with DPN, and found that the total incidence of foot lesions and ulcers did not significantly differ between groups. However, Balducci et al. [15] studied long-term brisk walking on a treadmill and reported that such an exercise intervention could improve the hallux vibration perception threshold of people with diabetes.

There was no conclusive evidence regarding the types of exercise that were useful for diabetic foot ulcer prevention. Further research in this area is therefore needed. A previous study has shown that weight-bearing exercise on an elastic surface can help to reduce contact pressure between the foot and ground.[20] Recently, the benefits of trampoline exercise were presented in some specific subject groups including improved balance control among older adults,[17] decreased cervical muscle spasm in fighter pilots,[16] and improved foot function in athletes with ankle instability.[21] To our knowledge, research studies examining the effects of trampoline exercise on foot care are unavailable. According to the evidence, exercise on a mini-trampoline promotes muscle strength, balance, and joint mobility. Therefore, we anticipated that exercise on a mini-trampoline might help patients with DPN to prevent foot ulceration by reducing neuropathic symptoms and high plantar pressure, as well as increasing foot and ankle strength. This study aimed to investigate the effects of a mini-trampoline exercise program on increasing foot mobility, decreasing peak plantar pressure, and enhancing sensation perception of people with DPN.

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Conclusion

The aim of this study was to investigate the effects of a weight-bearing exercise program, using a mini-trampoline, on 1st MTPJ ROM, peak plantar pressure and sensation perception in patients with DPN. The results showed that the program could decrease the feeling of numbness, and the number of people with DPN with impaired pressure and vibration perception within a relatively short period of time. Additionally, the exercise could increase 1st MTPJ flexion and extension. There was a trend for a reduction of peak plantar pressure in the medial forefoot of exercising subjects. It is feasible that a simple home exercise program using a mini-trampoline could provide the benefits of fewer foot ulcerations in people with DPN.

PART II. Below is an article published in 2017, entitled "Short-term motor learning and retention during visually guided walking in persons with multiple sclerosis" by McGowan K. *et al.* at Neurorehabilitation and Neural Repair, 31(7):648-656. doi: 10.1177/1545968317712472. Epub 2017 Jun 6.

Based on the content of the reading material, please answer the following **THREE** questions in Chinese or English. (50%)

Q1. Please summarize the background and purpose of this study in Chinese. You may not translate the paragraphs word by word. (20%)

Introduction

Walking ability and visual function are major concerns among persons with multiple sclerosis (PwMS) and are noted as the most important attributes to functional independence and quality of life.[1-3] Impairments in walking range from reduced speed to greater joint angle variability to changes in spatial-temporal step metrics.[4-10] Many of these gait impairments are evident even in PwMS with minimal disability.[4,6,7,9] Visual impairments are also common among PwMS, often secondary to optic neuritis.[11,12] These factors, among other sensorimotor deficits, contribute to the high risk of falling in this population.[13-15] For instance, variability in the location of foot placement while walking is significantly greater in PwMS classified as recurrent fallers compared to nonfallers as well as healthy controls.[8] Rehabilitation strategies may help improve motor function despite these issues, and the development of these interventions would likely benefit from a better understanding of motor learning in this population.

Spontaneous recovery of function and rehabilitation rely on the nervous system's capacity for neural plasticity and its ability to adapt. Sensorimotor adaptation—one form of motor learning—involves modifying movement patterns based on altered sensory input and/or motor function as a result of neurological injury or novel environmental constraints.[16,17] The brain may use the error between the predicted outcome of a movement and the actual observed outcome to drive the adaptation.[16,18] This process occurs relatively rapidly over repeated movements to achieve a certain level of performance, and which we define here as short-term motor learning. When adaptation occurs because of neurological injury, it is desirable for both the patient and the therapist that performance gains are retained over days, weeks, months, and so on. Maintaining these abilities is thus important for PwMS to attain benefits from rehabilitation. However, research on motor learning in PwMS is limited, has focused predominantly on upper limb or standing balance tasks, and has largely neglected longer-term retention. These studies have generally found that motor learning is preserved in PwMS when compared to healthy controls,[19-24] with a few exceptions,[21,25,26] despite many showing worse motor performance in PwMS on the specific task at baseline and/or throughout testing. For instance, Casadio et al[19] demonstrated that PwMS with no or minimal clinical disability are able to adapt to a velocity-dependent force field in a reaching task similarly to controls, although with greater movement variability. In addition, PwMS can learn an upper limb–based visuomotor tracking task to the same extent as controls.[23] Given the importance of visually guided walking for community ambulation, it is prudent to study motor learning in PwMS in this context as well.

The ability to coordinate visual information with movement is normally important to interact with the environment. Indeed, visually guided walking requires the brain to maintain an accurate relationship (or visuomotor mapping) between the perceived stepping location and the motor command necessary to direct the foot to that position on the ground with minimal error.[18,27-29] This is crucial to safely negotiate changes in terrain and obstacles, where appropriate foot placement is paramount.[30,31] Interestingly, PwMS with mild-to-moderate disability walk with greater head pitch downward and with the head and body center of mass positioned closer to the toe of the stance foot when in swing phase.[32-34] These authors suggest that this strategy allows PwMS to better visualize foot placement.

In this study, to study motor learning in PwMS, we used prism lenses to alter the visuomotor mapping during a precision walking task that involved stepping to the center of targets. This led to errors in foot placement on initial exposure. Specifically, we tested the hypotheses that PwMS are able to adapt to, and retain over a 1-week period, a novel visuomotor mapping but will adapt more slowly and exhibit less retention compared to healthy controls. The ability to predict which patients are more likely to show greater motor learning may help clinicians prescribe and administer better rehabilitation protocols, both in terms of type and duration. Thus, we also tested the hypothesis that clinical measures used to characterize function in PwMS predict retention capability.

Q2. Please explain the experimental procedure using a flow chart. (20%)

Materials and Methods

Participants

Nineteen PwMS (mean age = 42.1 ± 9.1 years, range = 22-54 years; 12 females; 17 relapsing-remitting type, 2 primary-progressive type) recruited from the Fraser Health Multiple Sclerosis Clinic (Burnaby, Canada) and 17 healthy controls of similar age and gender (mean age = 41.6 ± 11.0 years, range = 23-54 years; 10 females) recruited from the Simon Fraser University community and surrounding area participated in this study. We used a convenience sampling method to recruit both groups. The Fraser Health Research Ethics Board and Office of Research Ethics at Simon Fraser University approved this study, and all participants gave informed written consent before testing.

The inclusion criteria for PwMS included (1) clinically diagnosed multiple sclerosis based on the McDonald Criteria;[35] (2) free of another neurological or musculoskeletal disorder, or uncorrected vision problem that impaired walking; and (3) an Expanded Disability Status Scale (EDSS) score below 4.0. We chose to recruit PwMS with mild disability to minimize the impact of motor weakness interfering with their ability to perform the task. We included controls if they had no musculoskeletal or neurological disorder and no uncorrected vision problem.

Experimental Task and Protocol

Participants performed a precision walking task[27-29] characterized by walking across a 6-m path and stepping onto the center of 2 targets (15 × 30 cm) without stopping (Figure 1A). The second target was located at a distance of 90% of the participant's height of the greater trochanter from the floor and a 30° counterclockwise angle with respect to the plane of progression.

During the precision walking task participants wore goggles with either 20-D (11.4°) wedge prism lenses that shifted the visual perception of the target to the right with respect to its actual location (see Figure 1B), or flat lenses that did not shift perceived target position. The prism lenses altered the participant's normal visuomotor mapping, inducing movement errors when walking and stepping onto the perceived location of the targets. The goggles reduced a portion of the visual field such that they forced participants to look only through the lenses. Participants knew the goggles altered their vision, but they did not know how. The prisms enabled us to study short-term visuomotor adaptation and retention in a motor behavior (ie, walking) typically impaired and a primary concern in PwMS.

In each trial, participants started at random anterior-posterior locations within a 1.8- to 3-m distance from the first target to prevent them from learning a specific stepping sequence and to ensure that the task remained under visual guidance. We provided several (standardized) instructions to participants. Specifically, we instructed participants to step in the medial-lateral center of the targets and to not stop until taking at least one step after the second target. Although difficult, it is possible to bypass the effects of the prisms via rapid corrections of leg/foot trajectory during the step to a target if a person moves very slowly. Thus, we also instructed participants to walk at a quick and constant pace to minimize the possibility of these so-called online corrections of leg/foot trajectory. Participants walked with an average speed (±SD) of 1.14 ± 0.31 m/s (PwMS) or 1.23 ± 0.24 m/s (controls), and we verified the absence of sudden changes in foot-marker trajectory during steps to the targets to confirm the lack of online corrections. We also told participants to look down to see their feet make contact with the targets but provided no specific instruction to look anywhere as they approached. Participants kept their eyes closed before each trial and again when walking back (under experimenter guidance) to the start position to avoid adaptation between trials.

Participants experienced 25 baseline trials (with flat, 0-D lenses), 60 adaptation phase trials (with 20-D lenses), and one postadaptation trial (with flat, 0-D lenses) in the first testing session (Figure 1B). In the second testing session 1 week later, participants experienced the same 60 adaptation trials followed by 5 postadaptation trials (with 0-D lenses). An Optotrak Certus motion capture camera (Northern Digital Inc, Waterloo, Ontario, Canada) recorded infraredemitting diodes secured to the chest and bilaterally on each mid-foot at a sampling frequency of 100 Hz.

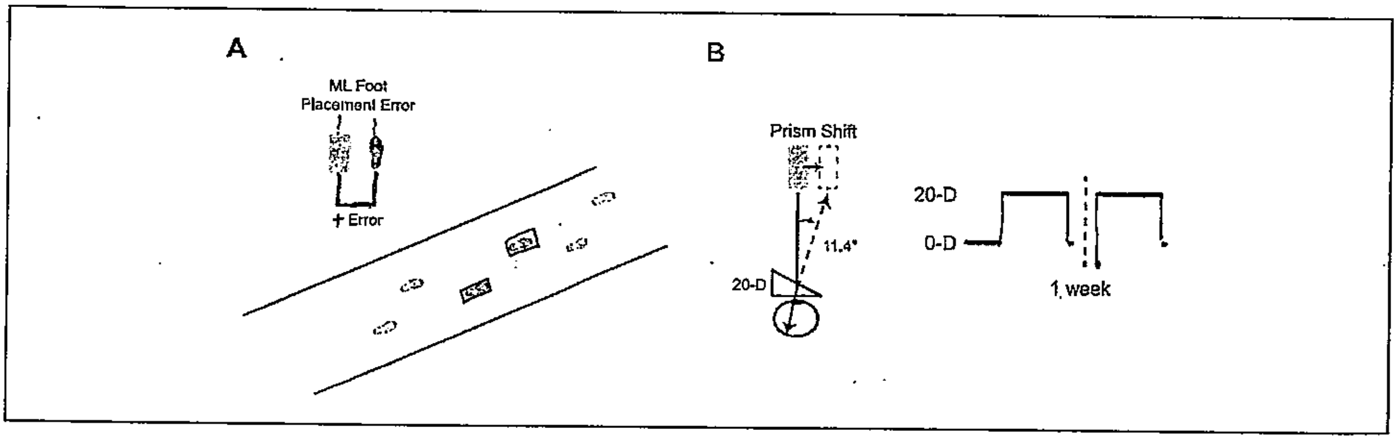

Figure 1. Experimental setup and protocol. (A) Schematic of the visually guided walking task. PwMS and controls walked and stepped onto 2 targets on the ground. Medial-lateral foot placement error, defined as the distance between markers on the foot and center of the targets, quantified performance. (B) A simulated view of the target through the prism lenses, and the perceived target shift for 20-diopter (20-D) lenses. In this protocol, subjects experienced 25 baseline trials, 60 adaptation trials (denoted by the step impulse in the illustration), and a single postadaptation trial on day 1. One week later, subjects experienced the same 60 adaptation trials followed by 5 postadaptation trials.

Clinical Measurements

PwMS also underwent a series of clinical assessments, completed within 6 weeks of the precision walking task. This included the latency—in both eyes—of visual evoked potentials (VEPs), where we used the value for the worst eye, and the Multiple Sclerosis Functional Composite (MSFC) assessment, which consists of the paced auditory serial addition test, the 9-hole peg test, and the timed 25-foot walk.[36] To assess functional mobility, PwMS performed the Six Spot Step Test (SSST), a timed walking test that involves kicking over a number of targets placed along a 5-m path,[37] and the Timed Up and Go (TUG) test.[38] To assess visuomotor coordination, we tested reaction time using the Dynavision D2 apparatus (Mode A; Dynavision International LLC, West Chester, OH), where participants press, as quickly as possible, targets that light up in different positions in front of them while standing. An experienced neurologist determined the EDSS score. Details are shown in Table 1.

Table 1. PwMS Characteristics[a].

Test/Assessment	Values
EDSS	2.0 (0-3.0)
MSFC (composite score)	0.58 ± 0.45
Visual Evoked Potential, worst eye (s)	107.0 ± 10.5
Six Spot Step Test (s)	7.06 ± 1.23
Timed Up and Go Test (s)	5.78 ± 1.02
Visuomotor Reaction Time (s)[b]	1.21 ± 0.37

Abbreviations: PwMS, persons with multiple sclerosis; EDSS, Expanded Disability Status Scale; MSFC, Multiple Sclerosis Functional Composite.

[a] Values are mean ± standard deviation or median (range). The clinical mobility assessment values are within normal ranges.

[b] Using the Dynavision D2 apparatus, Mode A.

Q3. Please explain the findings of Figure 2 in your own words. (10%)

Results

Adapting to a Novel Visuomotor Mapping During Precision Walking

We found no differences in baseline mean foot placement error (PwMS = −7.2 ± 24.2 mm vs controls = 0.5 ± 13.5 mm; $t_{29} = -1.2$, $P = .243$) or error variability (PwMS = 20.2 ± 6.6 mm vs controls = 18.5 ± 5.1 mm; $t_{33} = 0.85$, $P = .401$) between PwMS and controls. Both groups demonstrated large initial foot placement error when exposed to the prism lenses in the adaptation phase but this error decreased over repeated trials. In the postadaptation phase, we found a large error in the opposite direction, suggesting that both groups stored the novel visuomotor mapping. These results are illustrated in Figure 2A. We found no significant Group main effect ($F_{1,34} = 0.03$, $P = .871$) or Group × Phase interaction ($F_{4,136} = 0.9$, $P = .484$). However, as shown in Figure 2B, we found a significant main effect of Phase ($F_{4,136} = 359.6$, $P < .0001$). Post hoc tests indicated greater error in the first adaptation trial compared to the rest ($P < .0001$). Error at baseline matched that in late adaptation though ($P = .913$). Furthermore, error differed significantly between early adaptation and the other phases ($P < .0001$). We found a similar effect for the postadaptation phase. Although both groups adapted to the prisms, it is possible that the rate at which they accomplished this differed. However, we found no differences between PwMS and controls for response time ($t_{34} = 0.47$, $P = .638$). This measure, which reflects the time it takes foot placement error to reach a plateau during the adaptation phase, is shown in Figure 2C.

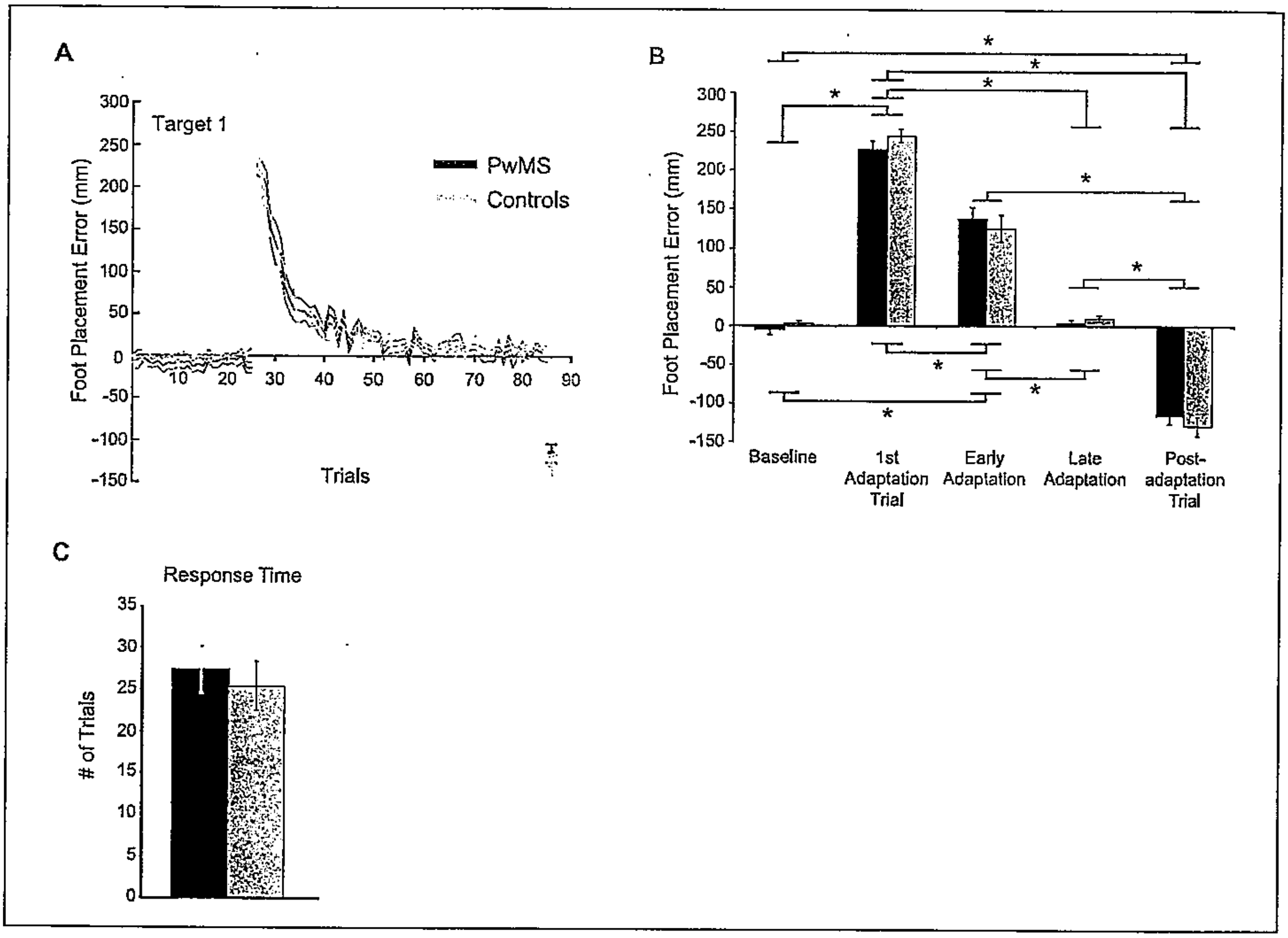

Figure 2. Adapting to a novel visuomotor mapping. (A) Group mean ± SE foot placement error related to target 1 during learning (day 1) for PwMS (black line) and controls (gray line) is shown. (B) Group mean ± SE foot placement error in different phases (baseline, first adaptation trial, early adaptation, late adaptation, postadaptation trial) for PwMS (black bars) and controls (gray bars). Asterisks indicate significant post hoc tests for the main effect of Phase ($P < .05$). (C) Group mean ± SE response time for PwMS (black bars) and controls (gray bars) are shown.