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Clinical Study

Mood and Balance are Associated with Free-Living Physical Activity of People after Stroke Residing in the community

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Purpose. To determine which characteristics are most associated with free-living physical activity in community-dwelling ambulatory people after stroke. *Method*. Factors (age, gender, side of stroke, time since stroke, BMI, and spouse), sensory-motor impairments (weakness, contracture, spasticity, coordination, proprioception, and balance), and non-sensory-motor impairments (cognition, language, perception, mood, and confidence) were collected on 42 people with chronic stroke. Free-living physical activity was measured using an activity monitor and reported as time on feet and activity counts. *Results*. Univariate analysis showed that balance and mood were correlated with time on feet ($r = 0.42, 0.43$, $P < 0.01$) and also with activity counts ($r = 0.52$, 0.54, $P < 0.01$). Stepwise multiple regression showed that mood and balance accounted for 25% of the variance in time on feet and 40% of the variance in activity counts. *Conclusions*. Mood and balance are associated with free-living physical activity in ambulatory people after stroke residing in the community.

1. Introduction

The importance of physical activity to health is well established. After stroke, regular physical activity is critical for regulating blood glucose and promoting decreases in body weight, blood pressure, level of total blood cholesterol, serum triglycerides, and low-density lipoprotein cholesterol [1]. There is evidence from a meta-analysis of cohort studies that sufficient physical activity has a protective effect against stroke [2]. Therefore, it has been suggested that physical activity could decrease the incidence of recurrent strokes and coronary events [3]. However, many individuals with stroke are sedentary—both before and after the stroke—and their free-living physical activity is below the recommended level [4–6].

Walking performance has been found to be significantly associated with free-living physical activity in community-dwelling stroke survivors [7, 8]. However, this is perhaps not surprising given that physical activity is usually measured as steps per day. In other words, walking performance and physical activity are effectively two aspects of the same theoretical construct within the ICF classification [9], that is, activity limitations. One aspect is related to the individual's performance such as walking measured using a 10 m walk test or a 6 min walk test (i.e., what they *can* do). The other is related to quantity, such as the amount of physical activity carried out every day (i.e., what they *do* do). In other words, what stroke survivors can do predicts what they actually do.

However, less attention has been paid to the influence of impairments, that is, a loss or abnormality of body structure and function [9], on physical activity. After stroke, many individuals are left with impairments—both sensory-motor (such as muscle weakness, spasticity, contracture) and non-sensory-motor (such as aphasia, depression, and poor cognition). It is logical to assume that sensory-motor impairments will affect physical activity, through their influence on walking performance [10–13]. In general, the presence of non-sensory-motor impairments is associated with poorer outcomes [14]. However, little is known about the impact of non-sensory-motor impairments on free-living physical activity. Non-sensory-motor impairments may indirectly impact on physical activity as much as sensory-motor impairments do.

Personal factors (such as age, BMI, psychological characteristics, and social support) may influence physical activity after stroke. Although physical activity has not been investigated directly, the presence of a spouse at home and good social support have been found to predict the ability to carry out activities of daily living in the long term [15, 16].

Given that some impairments and personal factors are amenable to modification in people after stroke, an understanding of which of these are associated with free-living physical activity may assist in planning appropriately targeted interventions. Therefore, the aim of this study was to determine which impairments and/or personal factors are most associated with free-living physical activity in community-dwelling people after stroke.

2. Methods

2.1. Design. A cross-sectional observational study was carried out with community-dwelling people after stroke. Ambulatory people with chronic stroke were recruited from the local community within a major city. Personal factors and impairments were collected on one day, and free-living physical activity was collected over two days in the community. Each participant was randomly allocated a day of the week and wore the activity monitor on this day across two consecutive weeks. The days for measurement of free-living physical activity were counterbalanced across the week so that there was the same amount of data collected for each day of the week. Data were collected from 30 min after getting out of bed (i.e., after dressing) until 30 min prior to going to bed (i.e., before undressing). Participants were instructed to carry out their routine activities. All measurements for each participant were completed within a 2-week period.

2.2. Participants. People with stroke were included if they were within 1 to 5 years of their first stroke, over 50 years old, and able to walk 10 m independently without an aid. They were excluded if they could not speak English or if they were unable to follow instructions. Ethical approval was obtained from the Human Research Ethics Committee at the local institution. Informed consent was obtained from all participants before data collection commenced.

2.3. Outcome Measures

2.3.1. Personal Factors. Age, gender, weight, height, side of hemiplegia, time since stroke, and presence of spouse were collected. Weight and height were used to calculate BMI in kg/m^2.

2.3.2. Impairments. Eleven impairments were measured and were divided into two categories: sensory-motor (including muscle weakness, contracture, spasticity, loss of coordination, proprioception, and balance) and non-sensory-motor (including cognitive, language, perceptual, mood abnormalities, and loss of confidence). Measures were chosen on the basis that they were easy and quick to perform in the clinic (e.g., they did not require extensive equipment), that they measured the impairment directly (i.e., they were not a subsection of a larger scale), and where possible, that they were valid and reliable for use in neurological conditions or with elderly patients. One person took all measures in order to eliminate inter rater variability and where relevant; the affected leg was measured.

Strength of the knee extensors was measured using hand-held dynamometry [17] since knee extensor strength has been shown to be associated with walking ability after stroke [18]. Participants lay supine with the hip and knee flexed to 90° and the lower leg resting on a stool, and the dynamometer was placed on the anterior surface of the lower leg. Participants were instructed to perform two maximum voluntary contractions with a minutes rest in between; the highest reading in *N* was used for analysis.

Contracture of the plantarflexors was measured using the method of Moseley and Adams [19] since the plantarflexors are a common site of contracture in people with stroke [20, 21]. Participants were seated with their feet on a sliding board, knees flexed to 90°, and a weight of 5 kilograms on the top of the knee. The examiner slid one foot at a time back until the heel lifted off the ground and took a photo in the sagittal plane thereby producing a measure of passive range of dorsiflexion with a standardized force. The angle between the vertical and the lower leg was measured by an examiner blinded to side of hemiplegia, and the difference between the intact and affected ankle in degrees was used in the analysis.

Spasticity of the plantarflexors was measured using the Tardieu scale [22–24] since the plantarflexors are a common site of spasticity and the Tardieu Scale is capable of differentiating spasticity from contracture [25]. Participants lay supine and were instructed to relax while the examiner dorsiflexed the ankle as fast as possible. The quality of the muscle reaction to stretch was rated on a scale from 0 to 4 with 0 being normal [26].

Coordination of the lower limb was measured using the Lower Extremity Motor Coordination Test (LEMOCOT) [27]. Participants were seated and, after practicing with their unaffected leg, moved the big toe of the affected leg from one target to another 30 cm away as fast as possible for 20 seconds (measured with a stopwatch). The accurate hits were counted and converted to taps/second to be used in the analysis.

Proprioception of the knee joint was measured using a matching task [28] since absent proprioception in the knee joint is related to frequent falls in people after stroke [29]. Participants were blindfolded and seated, knees flexed to 90°, with a vertical clear acrylic sheet ($60 \times 60 \times 1$ cm) inscribed with a protractor placed between their legs. After a practice, the examiner moved the affected knee randomly to 5 angles between 20- and 60 degree-flexion and instructed participants to move the intact leg to align their big toes. The mean error in degrees in matching the knee angle was averaged over the 5 trials to be used in the analysis.

Balance was measured using a modified version of the Single Leg Stance Test [30]. Participants stood unsupported on the affected leg in bare feet, arms folded across their chest, and eyes focusing on a stationary visual target located on a wall one meter from their standing position, for as long as possible (up to 30 s). If the feet moved, the foot touched the floor, the legs touched each other, or the arms moved, the examiner stopped the test and asked the participant to do the test again. The longest duration in seconds from three trials was used in the analysis.

In terms of non-sensory-motor impairments, cognition was measured using the Mini-Mental State Examination (MMSE) [31], since it is a commonly used test. The examiner asked the participant 11 questions generating a score between 0 and 30, where 30 is normal and <24 is considered cognitively impaired.

Language was measured using the Frenchay Aphasia Screening Test (FAST) [32] since a review study conducted by Salter and colleagues [33] indicated that it was the most widely used and thoroughly evaluated language test in stroke research. The shortened version of the test was used (0 to 20) with 10 points allotted for comprehension and 10 points for expression.

Perception was measured as neglect using the Line Bisection Test adapted from Olk and Harvey [34], since it is a simple test and can be completed within a short period [35]. Participants sat on a chair and were instructed to bisect a 10 cm horizontal line as centrally as possible. The examiner then measured the distance between the bisection and the actual midpoint of the line, and the error in mm was used in the analysis.

Mood was measured using the 6-item self-report Short Depression-Happiness Scale (SDHS) [36] since it is a short test which is not particularly susceptible to memory impairments. Three items record positive thoughts and feelings while three items record negative thoughts and feelings over the past 7 days ranging from never (0), rarely (1), sometimes (2), and often (3). Items concerning negative thoughts and feelings are reverse scored so that the range of scores is 0 to 18, where poor mood or depression is defined as a score <10 [37].

Confidence was measured using the 10-item self-report General Perceived Self-efficacy Scale [37] since it measures confidence across life generally, rather than in specific tasks such as falling [38], self-care [39], or walking, climbing stairs, and lifting objects [40]. Participants rated their confidence in each item from not at all confident (1) to very confident (4), so that the range of scores was 10 to 40, where 10 is the lowest confidence.

2.3.3. Free-Living Physical Activity. Free-living physical activity was collected using an activity monitor-Intelligent Device for Energy Expenditure and Activity (IDEEA). This device is light (58 g), and the recorder is clipped to the belt or waist of the pants. It monitors body motion through five sensors attached to the front of the chest, to the front of both thighs, and underneath both feet using medical tape. Postures (lying, reclining, sitting, standing, and leaning), transitions (lie to sit, sit to lie, recline to sit, sit to recline, recline to stand, stand to recline, sit to stand, and stand to sit), and gait (walking, running, up and down stairs, and jumping on both legs) are measured. An investigator visited participants' homes and calibrated the device. The recording of physical activity was then begun, with the investigator returning to turn the device off and check the data at the end of the day. Free-living physical activity was reported as duration (time on feet and time not on feet) and frequency of activity (activity counts) carried out per person per day [41]. "Time on feet" was measured in minutes and comprised the time spent walking, going up and down stairs, standing, and in sit to stand transitions. "Time not on feet" comprised time spent sitting, reclining, and lying down. "Activity counts" comprised the number of steps walked, stairs ascended and descended, and number of sit to stand transitions.

The IDEEA has been found to be >98% accurate for duration, frequency, type, and intensity of a variety of physical activities in normal adults [42] and reliable and valid for measuring walking in people after stroke [43]. We also compared the IDEEA with direct observation in three people after stroke with varying walking abilities. There are two algorithms available for use, with one being more sensitive to pathological movement. When using this algorithm, we found that the accuracy of duration of physical activity was 99% and of frequency of physical activity was 94%. Given that there was some variability of physical activity over the two days of measurement ($ICC_{3,1}$ 0.68 to 0.80), data were averaged over these days to present the breadth of activity.

2.4. Data Analysis. We collected data on 42 participants so that if up to 8 variables were entered into the regression analysis, there would be at least 5 cases per independent variable [44]. In addition, 42 participants meant that each day of the week is represented by data from 6 participants.

Shapiro-Wilk normality test was used to determine if the free-living physical activity data was normally distributed. It showed that the variable "activity counts" was positively skewed. When a log transformation was performed which normalized the activity counts data, there was no difference in the regression results. That is, the deviation from normal was not so large as to affect the outcome of the analysis. Therefore, the original data was used in order to facilitate interpretation.

Univariate analysis was undertaken using Pearson's correlation coefficient to examine the association between characteristics and free-living physical activity. Characteristics with correlations of $P < 0.05$ were entered into multivariate analysis. Stepwise multiple regression analysis was used to examine which characteristics were independently associated with free-living physical activity ($P < 0.05$) or explained an additional 5% of the variance.

3. Results

3.1. Participants. Forty-two stroke survivors aged 70 years (SD 10) with a BMI on the upper limit of normal participated in this study (Table 1). Over two-thirds of the participants were male; approximately half were right hemiplegics and

Table 1: Characteristics of participants.

Characteristic	Participants (n = 42)
Personal factors	
Age (yr), mean (SD)	70 (10)
Gender, n male (%)	29 (69)
Weight (kg), mean (SD)	73 (12)
Height (m), mean (SD)	1.7 (0.1)
Side of hemiplegia, n right (%)	23 (55)
Time since stroke (yr), mean (SD)	2.8 (1.4)
BMI (kg/m^2), mean (SD)	26.4 (4.3)
Living with spouse, n yes (%)	37 (88)
Impairments	
Sensory-motor impairments, mean (SD, range)	
Strength (N)	116 (52, 53–303)
Contracture (°)	4.8 (4.8, 0–19)
Spasticity (0 to 4)	1.2 (1.0, 0–3)
Coordination (taps/s)	0.6 (0.4, 0–1.6)
Proprioception (°)	4.2 (2.6, 0–12.6)
Balance (s)	5 (7, 0–30)
Non-sensory-motor impairments, mean (SD, range)	
Mood (0 to 18)	11 (4, 3–18)
Confidence (10 to 40)	29 (5, 17–39)
Perception (mm)	2.2 (1.6, 0–5)
Cognition (0 to 30)	25 (3, 17–30)
Language (0 to 20)	17 (4, 2–20)
Free-living physical activity over waking day, mean (SD, range)	
Time on feet (min)	230 (115, 29–506)
Activity counts (#)	5656 (4091, 543–18804)

the majority lived with their spouse. On average, participants had strong knee extensors, mild contracture of the plantarflexors, some spasticity, poor coordination, and normal proprioception in the affected leg. Their ability to balance was poor with 6 (14%) participants not being able to stand on their affected leg.

The mood score of 18 participants (43%) was below 10 which fulfills the criteria for depression. Most of the participants were confident and most also bisected the horizontal line within 5 mm of the middle, suggesting good perception. On average, the cognitive score was within normal limits; however, the scores of 11 (27%) participants were <24 suggesting the presence of cognitive impairment in some participants. Moreover, the Frenchay Aphasia Screening showed that 8 (19%) participants had language impairment.

The mean duration of free-living activity monitored was 10.8 hr/day (SD 1.3). On average, participants spent 230 min (SD 115) on their feet which was 35% of the monitored time. On average, they registered 5656 activity counts (SD 4091).

Table 2: Univariate analysis of the correlation between characteristics and free-living physical activity using Pearson's correlation coefficient r (P).

Characteristic	Free-living physical activity	
	Time on feet	Activity counts
Personal factors		
Age	−0.18 (0.26)	−0.26 (0.09)
Gender	0.10 (0.52)	0.17 (0.28)
Side of hemiplegia	0.12 (0.45)	0.00 (0.99)
Time since stroke	0.00 (0.99)	−0.03 (0.85)
BMI	−0.29 (0.06)	−0.12 (0.45)
Living with spouse	0.00 (0.98)	0.12 (0.44)
Impairments		
Sensory-motor impairments		
Strength	0.18 (0.25)	0.03 (0.85)
Contracture	−0.28 (0.07)	−0.27 (0.09)
Spasticity	−0.15 (0.33)	−0.21 (0.18)
Dexterity	0.10 (0.52)	0.15 (0.33)
Proprioception	0.07 (0.68)	−0.02 (0.89)
Balance	0.42 (<0.01)	0.54 (<0.001)
Non-sensory-motor impairments		
Mood	0.43 (<0.01)	0.52 (<0.001)
Confidence	−0.03 (0.84)	0.09 (0.57)
Perception	−0.13 (0.42)	−0.26 (0.10)
Cognition	0.18 (0.25)	0.03 (0.85)
Language	0.11 (0.50)	−0.04 (0.80)

3.2. Prediction of Free-Living Physical Activity. Univariate analysis showed that balance and mood were significantly correlated with time on feet (r = 0.42, 0.43, P < 0.01) and balance and mood were also significantly correlated with activity counts (r = 0.52, 0.54, P < 0.01). No other impairment or personal factor were correlated with either time on feet or activity counts (Table 2).

When the characteristics that were correlated with time on feet (P < 0.05, i.e., balance and mood) were entered into multiple regression, mood was independently associated with time on feet, with a regression coefficient of 8.2 (95% CI 0.2 to 16.2). Balance was not significantly associated with time on feet; however, it accounted for an additional 7% of the variance in time on feet. Balance and mood together accounted for 25% of the variance in time on feet.

Similarly, when the characteristics that were correlated with activity counts (P < 0.05, i.e., balance and mood) were entered into multiple regression, balance and mood were both independently associated with activity counts, with regression coefficients of 227 (95% CI 74 to 380) and 337 (95% CI 88 to 586), respectively. Balance and mood together accounted for 40% of the variance in activity counts.

4. Discussion

The aim of this study was to determine which characteristics were most associated with free-living physical activity in community-dwelling people after stroke who could walk independently. Balance and mood were associated with free-living physical activity in community-dwelling stroke survivors, regardless of whether physical activity was measured as time being active or frequency of activity.

There was only one sensory-motor impairment—balance—that was associated with free-living physical activity such that the poorer the balance, the lower the amount of physical activity. Even though our sample could all walk 10 m unaided, standing on one leg was less than one quarter of normal performance in our participants [45]. Falls are common after stroke, and balance has been found to be an important risk factor for falls in stroke survivors [46]. Furthermore, balance has been found to be one of the independent predictors of satisfaction with community reintegration [47].

There was also only one non-sensory-motor impairment—mood—that was associated with free-living physical activity such that the greater the depression, the lower the amount of physical activity. 42% of our population met the criteria of depression, which is similar to findings from two community-based studies of poststroke depression [48, 49] and higher than two other studies [50, 51]. Moreover, there is evidence that the prevalence of depression increases over time after stroke [52, 53]. Previous research has shown that depression is also related to stroke recovery [54–56]. For example, Kotila et al. [57] found that depression is associated with poor recovery at one year after stroke in four different districts in Finland. In addition, two studies have found that people with depression at least one year after stroke are significantly more impaired in activities of daily living than those without depression [52, 58]. Similarly, others have found that participation restrictions are significantly correlated with depression [59].

The finding that balance and mood are associated with physical activity does not mean that depression and poor balance cause low levels of physical activity—the relationship is more likely to be cyclical. For example, if stroke survivors have poor balance, their physical activity is likely to be curtailed, which in turn may lead to a worsening in balance from lack of practice, thereby setting up a vicious cycle of deterioration in balance and physical activity. Similarly, depression can also curtail physical activity, which in turn may lead to further depression [60, 61].

In our study, spouse support was not correlated with free-living physical activity, which differs from Jorgensen and colleagues' [14] findings. One possible explanation may be that, in our study population, 88% lived with their spouses, which did not allow a thorough exploration of this variable. We also found a trend towards age and BMI negatively correlating with physical activity ($P = 0.09$ for age and 0.06 for BMI), in line with findings reported by Hagstromer and colleagues [62].

There are several implications from the findings of this study for clinicians involved in rehabilitation after stroke. Our findings suggest that intervention aimed at improving balance and enhancing mood may be useful in promoting long-term physical activity. Although the evidence for the benefit of exercise in managing depression is not clear-cut in the nonstroke population [63], there is some evidence that it may be effective in stroke [64–68]. In addition, there appears to be a small benefit for strategies such as education and advice targeting emotional recovery and adjustment to the impact of stroke [69]. Establishing supportive programs for community-dwelling stroke survivors is likely to decrease the rate of depression. There is evidence that community-dwelling stroke survivors who live in places with supportive programs (that encourage them to actively participate in social activities and provide any help they need for adapting to life) had better mood scores than those who live in the districts without such supportive programs [57]. More recently, Pakkala et al. [70] found that stroke survivors who were involved in a free-living physical activity counseling programs demonstrated lower depressive symptoms than controls.

The strengths of this study were that an activity monitor was used to measure free-living physical activity by which the limitations of self-report methods such as recall bias was avoided [8]. The limitations of this study include the relatively small sample size. However, by performing a univariate analysis to eliminate nonsignificant variables, there was sufficient power to conduct a stepwise regression analysis. Furthermore, the participants were recruited from the community, so that, while we measured the level of their disability, we have no information about the specific site and size of their lesion.

5. Conclusion

We have found that balance and mood were associated with free-living physical activity in community-dwelling people after stroke who can walk independently. These findings provide guidance to professionals working in rehabilitation in appropriately targeting intervention. Further research is required to examine prospectively whether early intervention to improve mood and balance will increase free-living physical activity of this population.

Conflict of Interests

The authors certify that no party having a direct interest in the results of the research supporting this paper has or will confer a benefit on them or on any organization with which we are associated.

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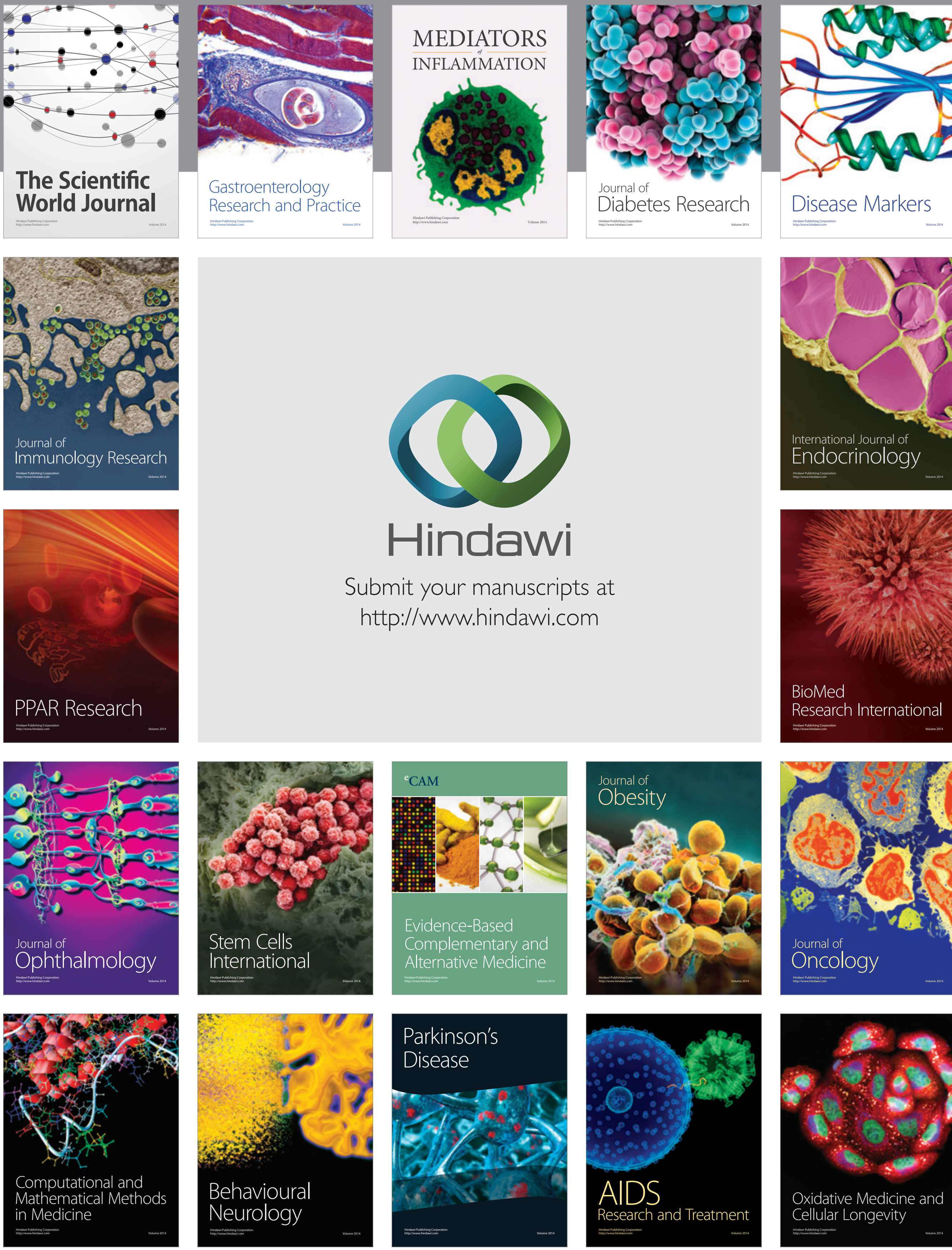
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