Irish Business Journal

Volume 7 | Number 1 Article 2

1-1-2012

Comparative Study: The Impact of the SW3 Armband and Physical Activity Logbook in Promoting Physical Activity Adherence

Bernie Cunningham

Suzanne Kennedy

Joseph English

Humphrey Murphy

A Comparative Study: The Impact of the SW3 Armband and Physical Activity Logbook in Promoting Physical Activity Adherence

Bernie Cunningham, Suzanne Kennedy, Dr Joseph English, Humphrey Murphy

Abstract

The purpose of this study is to compare the impact of portable body sensing technology (SW3 Armband) to a traditional approach, a Physical Activity Logbook (PAL) in promoting physical activity adherence. Participant's physical activity adherence levels were recorded over a six month period. The primary research involved a six month physical activity programme that commenced in October 2010 and finished in April 2011. Females (n=30) were recruited through a local newspaper and a radio advertisement. Participants were randomised to an Intervention Group (n=15) or a Control Group (n=15). To be eligible to participate in the study the following criteria applied: (1) age range: 30-50 years, (2) gender: female, (3) location: live in the Letterkenny or surrounding area, (4) physical activity levels: did not meet the World Health Organisations (WHO, 2011) recommendations for physical activity, (5) have access to windows XP. Participants were assessed at Baseline, Time 1 (week eight), Time 2 (week eighteen) and Time 3 (week twenty-six) regarding the amount of physical activity minutes accumulated. The results of this study specify that the Control Group (CG) performed a greater amount of moderate intensity minutes of physical activity compared to the Intervention Group (IG). At the end of Time 3, the CG was performing three times more moderate physical activity than that of the IG. Therefore, the traditional method of a PAL has proved to be an effective method of promoting physical activity adherence when compared to that of the SW3 Armband. The SW3 Armband is a wireless technological device consisting of an armband worn on the upper right arm and a wrist watch. The SW3 Armband and wrist watch displays real time, collective and significant data such as daily step count and minutes of moderate and vigorous physical activity.

Keywords: *Physical Activity, Physical Activity Logbook (PAL), SW3 Armband*

Introduction

According to the World Health Organisation (WHO, 2011) approximately 31% of adults worldwide fail to meet the minimum recommendations for health related physical activity, and 46% of Irish adults do not meet the guidelines (SLAN, 2007). The WHO (2011) minimum physical activity recommendations designed for health benefits for adults aged between eighteen and sixty-five are as follows:

Minutes	Intensity	Days per week
30	Moderate	5
OR		
25	Vigorous	3
AND		
Muscular endurance training at least two days or more per week		

Table 1: World Health Organisations (WHO, 2011) Guidelines for Minimum Physical Activity

How Much Physical Activity?

Trying to support individuals to initiate and maintain physical activity in the long term is a challenge (Brawley *et al*. 2003, Marcus *et al*. 1998 and Hasler *et al*. 2000). As individuals age their participation in physical activity drops off (Hughes *et al*. 2008 and Thurston & Green, 2004). Thirty minutes of moderate intensity physical activity on most days of the week is considered as a sufficient amount of physical activity for health benefits (Pate *et al*. 1995). Authors vary in their opinions about the type, duration, and intensity of physical activity. Jakicic *et al*. (1999 and 1995) report that short bouts of moderate cardiovascular physical activity (i.e. 4 by 10 minutes daily) assist in promoting physical activity adherence, compared to one forty minute session of physical activity. The WHO (2011) have adopted the findings of the ACSM (2008) who recommend that thirty minutes of physical activity per day will provide health related benefits. Research studies accept these guidelines from the WHO (Frank *et al*. 2005, Schumann *et al*. 2003 and Dunn *et al*. 1999) but also acknowledge that short bouts are sufficient to achieve physiological and psychological benefits of physical activity (Jackicic *et al*. 1999 and 1995).

Research signifies that females are the least active segment of the population and consequently are at a greater risk of developing diseases that are associated with a sedentary lifestyle (Findorff *et al*. 2009, Arbour & Ginis, 2009, Aaron *et al*. 1995 and Bonheur & Young, 1991). In Ireland, ten thousand people die each year from cardiovascular disease (Irish Heart Foundation, 2010). Participation in regular physical activity can enhance health and induce a greater lifespan (Paffenbarger *et al*, 1993).

Subjective and Objective Measurement Tools

Traditionally, physical activity has been measured via subjective measurements such as questionnaires and record logbooks. Questionnaires have been a popular research tool (Philippaerts *et al*. 2001 and Elosua *et al*. 2000). However, participants self-report their physical activity levels and can over estimate their physical activity minutes which can often decrease accuracy of results (Aoyagi & Shepard, 2009). Research indicates that a combination of subjective and objective data collection enhances the accuracy of measuring physical activity (Harris *et al*. 2008 and MacFarlene *et al*. 2006).

More recently, objective measurements such as accelerometers and the SW3 Armband have been introduced to assess physical activity (Taraldsen *et al*. 2011, Andre *et al*. 2006, Bassett 2000 and Sallis & Saelens, 2000). Wearable body sensor devices are been used increasingly in medical and clinical settings to monitor and analyse body functions (De Bruin *et al*. 2008, Corder *et al*. 2007, Stovitz *et al*. 2005 and Bjorgaas *et al*. 2004). Research by Liden *et al*. (2002, p.1) suggests that 'As technology rapidly decreases in size, wearable monitoring devices has become a viable and practical reality', allowing individuals to wear body sensor devices for extended periods. Motion sensor devices have provided greater accuracy in detecting physical activity patterns in a wide variety of settings (Clemes *et al*. 2008, Gerdhem *et al*. 2008 and Steele *et al*. 2003). Additionally, technological devices have a positive affect on adherence levels, preventing drop-outs from programmes (Henderick *et al*. 2010). King *et al*. (2008, p.138) state that 'few systematic efforts to evaluate the efficacy of hand-held computers and similar devices for enhancing physical activity levels have occurred'. Consequently, this study evaluated the effectiveness of the SW3 Armband in promoting physical activity adherence in comparison to a PAL.

A range of studies to date have used subjective measures to quantify participation levels in physical activity (Schumann *et al*. 2003, Elosua *et al*. 2000 and Sarkin *et al*. 2000). The measurement of physical activity objectively through the use of a technical device is more accurate than assessing physical activity through a formal questionnaire (Bassett *et al*. 2000). Technological devices that are accompanied by a formal instrument such as a PAL can help highlight the significance of physical activity adherence issues (Tudor-Locke & Lutes, 2009, Lauzon *et al*. 2008; Tudor-Locke *et al*. 2000).

Portable body sensing technology may assist in motivating individuals to adhere to physical activity because of the real time physiological data that the user can access (Baker *et al*. 2008, Bravata *et al*. 2007, Merom *et al*. 2007; Mutrie *et al*. 2004; Tudor-Locke, 2002). A range of studies to date have used subjective measures to quantify participation levels in physical activity (Lawerence & Shank, 1995). Future research studies on physical activity adherence should consider incorporating a combination of both subjective and objective methods in order to increase our understanding of the effectiveness of such technological devices and formal instruments.

The SW3 Armband and Physiological Characteristics

With advancements in technological innovation, physical activity is becoming easier to monitor and analyse. Marketable devices such as pedometers, accelerometers and more recently the SW3 Armband provide individuals with real time physiological data and are accessible to the recreational enthusiast. According to King *et al*. (2008, p. 138) 'efforts to achieve population wide increases in physical activities potentially can be enhanced through relevant applications of interactive communication technologies'. Research has shown that motion sensors are a valid and reliable means of gathering data (Bender *et al*. 2005, Duncan *et al*. 2005; Yamanouchi *et al*. 1995).

The SW3 comprises an armband worn on the upper right arm and a wrist watch display. The SW3 is a wireless device comprising a transmitter worn on the upper arm that captures real time, collective and significant data. It is recommended that the SW3 is worn twenty four hours per day and is only removed when the individual is bathing or swimming. The data stored can be acquired by connecting the armband to a computer system and using the online activity manager to download and access the information. Real time data such as how many steps an individual has taken within twenty four hours can be retrieved in real time from the wrist watch display. The SW3 has been clinically validated to be over ninety per cent accurate when determining calorie burn (Johannes, 2009).

Kasabach *et al*. (2002, p. 2) noted that 'energy expenditure, level of physical activity, sleep quality, heart rate, stress, and contextual awareness were the most significant states worth obtaining continuously'. The SW3 processes the following information: (i) Total Energy Expenditure and Active Energy Expenditure, (ii) Duration of Physical Activity, (iii) Sleep Duration, (iv) Number of Steps, (v) Duration the SW3 Armband is worn. The SW3 Armband provides an easy and efficient digital device to individuals to assess daily physiological characteristics (Andre *et al*. 2006) and can offer assistance to health and fitness instructors in supporting clients to make healthier lifestyle choices. This information can be captured and calculated every minute of the day as long as the user is wearing the armband (Fruin & Rankin, 2004). The SW3 captures averages and variances on all features, but also can detect peak phases (i.e. a day of the week in which a user has walked the most number of steps (Andre *et al*. 2006).

Research Methodology

The research study was completed by means of a quantitative approach. Participants were required to self-report their activity, duration and intensity of physical activity in their PAL's. The quantitative method involved analysing the accumulated minutes of moderate and vigorous physical activity within the PALs. These were collected at the end of T1 (week eight), T2 (week eighteen) and T3 (week twenty-six). All participants filled out a questionnaire regarding the ease of use of the PAL. The IG also completed a questionnaire on the ease of use of the SW3 Armband. Intensity of physical activity was measured using the Omnibus Scale of Perceived Exertion (OMNI), adult: walking to running format (Robertson, 2004). OMNI is short for 'omnibus' which means that the perceived exertion picture scale used to measure intensity is appropriate for a wide diversity of individuals and physical activity settings.

Participants

Female volunteers were recruited through local media inviting applicants to join the research programme. A total of eighty-nine volunteers applied for the programme, entitled 'Get Started and Stick with it'. Thirty females were selected from a total of the fifty-eight applicants that met the recruitment criteria. The researcher chose to use a set of random numbers proposed by Spiegel *et al*. (2008, p. 419) to select and assign participants at Baseline to one

of two treatment conditions. Participants in the IG had the use of a digital body monitoring device known as the SW3 Armband, in conjunction with a PAL that tracked their physical activity participation. The remaining fifteen participants in the CG did not have access to the SW3 Armband, but kept a PAL only. For the duration of the study a trained research assistant responded to queries from participants and withdrawals from the study. In addition, the research assistant completed four structured assessments with the participants at Baseline, at the end of T1, T2, and T3 and was responsible for distributing and administering the PALs and questionnaires.

Definition of Regular, Moderate and Vigorous Physical Activity

For the purposes of this study regular, moderate, and vigorous physical activity was defined as follows:

1. Regular physical activity was defined in accordance with the WHO (2011) recommended guidelines for physical activity of thirty minutes of moderate intensity physical activity five days per week OR an equivalent combination of moderate and vigorous physical activity.
2. Moderate physical activity exertion should result in being slightly out of breath and categorised from 'number five to number seven' on the Omnibus Scale of Perceived Exertion (Robertson, 2004).
3. Vigorous physical activity should result in deep rapid breathing and categorised from 'number eight to ten' on the Omnibus Scale of Perceived Exertion (Robertson, 2004).

Intervention Group and Control Group

The physical activity levels of participants (n = 30) in the IG and CG was assessed via a PAL. Participants followed a generic physical activity programme that included activities such as walking, swimming, home workout, fitness classes and an open activity option classified as 'other'. Participants recorded the type and duration of their physical activity and the intensity of their workouts in the PAL on a pre-determined scale (Robertson, 2004). Participants in the IG also had the use of the SW3 Armband and direct access to the data it stored, as a potential motivational tool to aid physical activity adherence. The difference between the IG and the CG was that the IG had the use of both a PAL and the SW3 Armband, whilst the CG had use of a PAL only as a means of potential motivation.

The Study: Baseline, T1 (week 1-week 8), T2 (week 9-week 18) and T3 (week 19-week 26)

Before commencing the programme participants were screened for any medical conditions using a Physical Activity Readiness Questionnaire. A summary of the purpose of the study and the benefits of physical activity was presented by the research assistant. The research

assistant inducted the relevant participants to the use of the PAL and the SW3 Armband. A generic fitness programme was given to participants. The research assistant supported the participants, offering an optional accompanied physical activity session once per week during the first eight weeks. At the end of T1 (week eight), the research assistant collected the PALs for the first eight weeks of the programme and the quantitative questionnaires on the use of the SW3 Armband and PAL were distributed and collected. An updated generic physical activity programmer was distributed to participants. Participants were also provided with a second PAL. The optional accompanied weekly physical activity session with the research assistant was discontinued after week eight. Support from the research assistant was also withdrawn after week eight. Participants who were having technical problems with the SW3 Armband or needed to contact the research assistant after T1, did so via email only, thus no direct contact.

At the end of T2 (week eighteen), the research assistant collected the PALs and the quantitative questionnaires on the SW3 Armband were distributed and collected for a second time. An updated generic physical activity programme was distributed to participants. Participants were also provided with a third PAL. At the end of T3 (week twenty-six), the research assistant collected the PALs and the quantitative questionnaires on the SW3 Armband were distributed and collected for a third time. Participants returned the SW3 Armbands and this marked the end of the twenty-six week research intervention. Participants were rewarded with a thank you card for their commitment to the programme.

Variable	Measure	IG	CG
Age (years)	Average	40.26	40.46
Work Status (%)	Employed Self-Employed Unemployed Student Housewife	60 0 20 7 13	53 7 27 0 13
Smokers (%)	Yes No	7 93	7 93
Marital Status (%)	Single Married Other	33 67 0	27 60 13
Baseline Activity	Sedentary	53	33
Level (%)	Irregularly active	47	67

Table 2: *Profile of Participants: Comparison between the Intervention Group (IG) and the Control Group (CG)*

Table 2 presents a demographic synopsis of all participants in the study. Participants' age, work, marital status and their physical activity levels before commencing the programme are displayed. As it is evident, similar findings can be found regarding the profile of the IG and CG in terms of age, work status, physical activity behavioural habit and marital status. The average age of participants in both groups was forty years of age. However, the table reports a difference between both groups baseline physical activity levels. The control group exhibited a significantly higher baseline activity level when compared to the intervention group. A significance difference was also notable at baseline regarding irregular activity, with the intervention group more likely to engage in irregular activity than the control group.

Findings

As stated previously, the aim of this quantitative study was to compare the impact of SW3 Armband to a PAL in promoting physical activity adherence. The findings are presented by comparing both groups' total accumulated minutes of moderate and vigorous physical activity. The effectiveness of using a PAL as part of a physical activity programme is examined and the efficacy of the SW3 Armband is also assessed.

Time	Moderate (IG)	Moderate (CG)	Vigorous (IG)	Vigorous (CG)
T1	5261	8248	870	1005
T2	5680	17745	1365	1125
T3	6980	20808	1695	1053
Total	**17921**	**46801**	**3930**	**3183**

Table 3: *The total accumulated minutes of moderate and vigorous physical activity performed over T1, T2, and T3 for both the IG and CG*

Table 3 provides evidence that the CG performed more moderate minutes of physical activity over T1, T2, and T3 compared to the IG. The most preferred activity was walking, followed by attending a fitness class (pilates, aerobics, and circuit training classes). Unseasonably heavy snowfall in the North West of Ireland in November and December, 2010 affected both groups physical activity patterns for a four week period. Both the IG and CG accumulated fewer minutes of vigorous physical activity over T1, T2 and T3. The IG accumulated more minutes of vigorous physical activity over T2 and T3 compared to the CG. At the end of T3, the CG had accumulated three times more moderate physical activity levels than the IG. Therefore, these results outline that given the conditions of this study, a PAL is a motivational tool in aiding physical activity adherence because the CG accumulated more minutes of moderate physical activity over the six month period of the study, compared to the IG. In addition, the CG met the WHO (2011) minimum recommendations for physical activity at the end of T3.

	Extremely Convenient		Convenient		Somewhat Convenient		Somewhat Inconvenient		Inconvenient		Extremely Inconvenient	
Group	IG	CG	IG	CG	IG	CG	IG	CG	IG	CG	IG	CG
T1 (%)	17	38	17	38	33	15	25	8	8	0	0	0
T2 (%)	25	33	25	33	42	25	0	0	8	8	0	0
T3 (%)	8	25	25	42	58	25	0	0	0	8	8	0

Table 4: *The percentage of participants in the IG and CG who found use of Physical Activity Logbook (PAL) to be convenient or inconvenient*

The majority of participants within both groups found that a PAL is a convenient method to track participation in physical activity. Few participants acknowledged the PAL as an inconvenience.

Group	IG	CG	IG	CG	IG	CG
Time	T1	T1	T2	T2	T3	T3
Yes (%)	42	38	25	58	17	33
No (%)	58	62	75	42	83	67

Table 5: *The percentage of participants in the IG and CG who completed their PAL daily*

Completing a daily PAL proved to be a challenge for participants in both groups. At the end of T3, 83% of participants in the IG and 67% of participants in the CG revealed that they did not complete a daily PAL. The PAL relies on a twenty-four hour recall; thus participants can overestimate or underestimate their physical activity levels by not completing their PAL daily (MacFarlane *et al*. 2006).

Group	IG	CG	IG	CG	IG	CG
Time	T1	T1	T2	T2	T3	T3
Yes (%)	50	69	42	75	58	67
No (%)	50	31	58	25	42	33

Table 6: *The percentage of participants in the IG and CG who found a PAL was a motivational tool for physical activity adherence*

The PAL is a consistent motivational tool and technique to record physical activity. At the end of T3, 58% of participants in the IG and 67% of participants in the CG found a PAL to be a form of motivation for physical activity adherence.

Time	Extremely Easy	Easy	Somewhat Easy	Somewhat Hard	Hard	Extremely Hard
T1 (%)	8	50	8	33	0	0
T2 (%)	33	17	25	25	0	0
T3 (%)	17	42	8	33	0	0

Table 7: *The percentage of participants in the IG that found the SW3 Armband easy or difficult to operate*

Table 7 shows that the majority of participants confirmed that the SW3 Armband is easy to operate. A small percentage of participants stated that the SW3 Armband was 'somewhat hard' to operate during T1, T2 and T3. Participants encountered some technical difficulties with the SW3 Armband during the programme and these issues were logged and resolved with the research assistant.

Did you find the SW3 Armband comfortable to wear?

Time	T1	T2	T3
Yes (%)	50	42	50
No (%)	50	58	50

Barriers associated with wearing the SW3 Armband

Time	Size	Irritating	Self-Consciousness	Dress Code
T1 (%)	8	33	8	17
T2 (%)	8	42	8	17
T3 (%)	8	42	8	17

Was the SW3 Armband a form of motivation for physical activity adherence?

Time	T1		T2	T3
Yes (%)	62		58	67
No (%)	38		42	33

Table 8: *The percentage of participants in the IG and their perception of the SW3 Armband as part of a physical activity programme*

Table 8 displays results relating to the comfort of wearing the device, the barriers relating to the SW3 Armband and the device as a supportive mechanism for promoting physical activity adherence. At the end of T3, 50% of participants acknowledged that the SW3 Armband was uncomfortable to wear; these figures were consistent for T1 and T2. As a result, participants perceived barriers to wearing the device. The main barrier to using the SW3 Armband was

irritation of the strap on the upper arm when worn for long periods of time. Although the SW3 Armband presents some barriers, 67% of participants found that the SW3 Armband was a motivational tool in aiding physical activity adherence. Conversely, 58% of participants in the IG found a PAL to be a motivational method of promoting physical activity adherence.

Conclusion

It can be concluded from the research that in the conditions imposed by the study, a traditional method of recording physical activity levels through the use of a PAL is more effective when compared to the SW3 Armband. The main barrier to wearing the SW3 Armband is 'irritation' of the upper arm caused when the device is worn for long periods of time. However, the SW3 Armband also acted as a motivational instrument but did not provide adequate support to assist participants in meeting the WHO (2011) physical activity guidelines.

Walking is a popular choice of physical activity for females in the age categories stated. Women are at a greater risk of developing cardiovascular disease and sustaining an inactive lifestyle (Findorff *et al*. 2009, Arbour & Ginis, 2009). Therefore, walking programmes and interventions should be administered in various physical activity settings to promote walking amongst female participants within this age range. This type of intervention offers greater potential in promoting physical activity and increasing female participation.

Future research studies could encourage the use of a PAL, especially for this age category (thirty to fifty years of age). Attitudes towards apprehensiveness in using technological devices to track physical activity adherence is also recommended. To tackle the burden of cardiovascular disease and associated mortality rates in Ireland amongst females, government agencies could focus on interventions that focus on walking, and physical activity tracking via a formal PAL, as a means of motivational support to increase physical activity levels.

References

Aaron, D. J., Kriska, A. M., Dearwater, S. R. (1993), 'The Epidemiology of Leisure Physical Activity in an Adolescent Population', *Medicine and Science in Sports and Exercise,* Vol. 25, No. 7, pp. 847-853.

Aaron, D. J., Kriska, A. M., Dearwater, S. R. (1995), 'Reproducibility and Validity of an Epidemiologic Questionnaire to Assess Past-Year Physical Activity in Adolescents', *American Journal of Epidemiology*, Vol. 142, No. 2, pp. 191-201.

American College of Sports Medicine. (2008), 2008 Physical Activity Guidelines for Americans, Retrieved7thNovember2011, from http://www.health.gov/paguidelines/guidelines/summary.aspx

Andre, D., Pelletier, R., Farringdon, J., Safier, S., Talbott, W., Stone, R., Vyas, N., Trimble, J., Wolf, D., Vishnubhatla, S., Boehmke, S., Stivoric, J., Teller, A. (2006), 'The Development of the SenseWear Armband, A Revolutionary Energy Assessment Device to Assess Physical Activity and Lifestyle', *BodyMedia*, pp. 1-17.

Aoyagi, Y., Shephard, R. (2009), 'Steps per Day: The Road to Senior Health', *Sports Medicine*, Vol. 39, No. 6, pp. 423-438.

Arbour, K. P., Martin Ginis, K. A. (2009), 'A Randomised Control Trial of the Effects of Implementation intentions on Women's Walking Behaviour', *Psychology and Health*, Vol. 24, No. 1, pp. 49-65.

Baker, G., Mutrie, N., Lowry, R. (2008), 'Using Pedometers as Motivational Tools: Are Goals Set in Steps More Effective than Goals set in Minutes for Increasing Walking', *International Journal of Health Promotion and Education*, Vol. 46, No. 1, pp. 21-26.

Bassett, D. R., Cureton, A. L., Ainsworth, B. E. (2000), 'Measurement of Daily Walking Distance: Questionnaire V's a Pedometer', *Medicine and Science in Sports and Exercise*, Vol. Vol. 32, No. 5, pp. 1018-1023.

Bender, J. M., Brownson, R. C., Elliot, M. B., Haire-Joshu, D. L. (2005), 'Children's Physical Activity: Using Accelerometers to Validate a Parent Proxy Record', *Medicine and Science in Sports and Exercise*, Vol. 37, No. 8, pp. 1409-1413.

Bjorgaas, M., Vik, J. T., Saeterhaug, A., Langlo, L., Sakshaug, T., Mohus, R. M., Grill, V. (2004), 'Relationship Between Pedometer-Registered Activity, Aerobic Capacity and Self-Reported Activity and Fitness in Patients with Type 2 Diabetes', *Diabetes, Obesity and Metabolism*, Vol. 7, pp. 737-744.

Bonheur, B., Young, S. W. (1991), 'Exercise as a Health-Promoting Lifestyle Choice', *Applied Nursing Research*, Vol. 4, No. 1, pp. 2-6.

Bravata, D. M., Smith-Spangler, C., Sundaram, V., Gienger, A. l., Lin, N., Lewis, R., Stave, C.D., Olkin, I., Sirard, J. R. (2007), 'Using Pedometers to Increase Physical Activity and Improve Health, A Systematice Review, *Journal of the American Medical Association*, Vol. 298, No. 19, pp. 2296 – 2304.

Brawley, L. R., Rejeski, W. J., King, A. C. (2003), 'Promoting Physical Activity for Older Adults: The Challenges for Changing Behaviour', *American Journal of Preventive Medicine*, Vol. 25, No. 3, pp. 172-183.

Clemes, S. A., Matchett, N.,Wane, S. L. (2008), 'Reactivity: Anissuefor Short-Term Pedometer Studies?', *British Journal of Sports Medicine*, Vol. 42, No.1, pp. 68-70.

Corder, K., Brage, S., Ekelund, U. (2007), 'Accelerometers and Pedometers: Methodology and Clinical Application', *Current Opinion in Clinical Nutrition and Metabolic Care*, Vol. 10, No. 5, pp. 597-603.

De Bruin, E. D., Hartmann, A., Uebelhart, D., Murer, K., Zijlstra, W. (2008), 'Wearable Systems for Monitoring Mobility Related Activities in Older People: A Systematic Review', *Clinical Rehabilitation*, Vol. 22, No. 10, pp. 878-895.

Duncan, S. C., Duncan, T. E., Strycker, L. A. (2005), 'Sources and Types of Social Support in Youth Physical Activity', *Health Psychology*, Vol. 24, No. 1, pp. 3-10.

Dunn, A. L., Marcus, B. H., Kampert, J. B., Garcia, M. E., Kohl III, H. W., Blair, S. N. (1999), 'Comparison of Lifestyle and Structured Interventions to Increase Physical Activity and Cardio Respiratory Fitness', *The Journal of the American Medical Association*, Vol. 281, No. 4, pp. 327 – 334.

Elosua, R., Garcia, M., Aguilar, A., Molina, L., Covas, M., Marrugat, J. (2000), 'Valaditation of the Minnesota Leisure Time Physical Activity Questionnaire in Spanish Women', *Medicine and Science in Sports and Exercise,* Vol. 32, No. 8, pp. 1431-1437.

Findorff, M. J., Wyman, J. F., Gross, C. R. (2009), 'Predictors of Long - Term Exercise Adherence in a Community - Based Sample of Older Women', *Journal of Women's Health.* Vol. 18, No. 11, pp. 1769 – 1776.

Frank, L. D., Schmid, T. L., Sallis, J. F., Chapman, J., Saelens, B. E. (2005), 'Linking Objectively Measured Physical Activity with Objectively Measured Urban Form', American Journal of Preventive Medicine, Vol. 28, No. 2, pp. 117-125.

Fruin, M. L., Rankin, J. W. (2004), 'Validity of a Multi-Sensor Armband in Estimating Rest and Exercise Energy Expenditure', *Medicine and Science in Sports and Exercise,* Vol. 36, No. 6, pp. 1063-1069.

Gerdhem, P., Dencker, M., Ringsberg, K., Akesson, K. (2008), 'Accelerometer Measured Daily Physical Activity among Octogenerians: Results and Associations to Other Indices of Physical Performance and Bone Density', *European Journal of Applied Physiology,* Vol. 102, No. 2, pp. 173-180.

Harris, T. J., Owen, C. G., Victor, C. R., Adams, R., Ekelund, U., Cook, D. G. (2008), 'A Comparison of Questionnaire, Accelerometer, and Pedometer: Measures in Older People', *Medicine and Science in Sports and Exercise'*, Vol. 41, No. 7, pp. 1392-1402.

Hassler, T., Fisher, B., MacIntyre, P., Mutrie, N. (2000), 'Exercise Consultation and Physical Activity in Patients with Type 1 Diabetes', *Practical Diabetes International,* Vol. 17, pp. 44–8.

Hughes, J. P., McDowell, M. A., Brody, D. J. (2008), 'Leisure-time Physical Activity among U.S Adults 60 or More Years of Age: Results from NHANES 1999-2004', *Journal of Physical Activity and Health,* Vol. 5, No. 3, pp. 347-358.

Irish Heart Foundation, (2010), 'Facts on Heart Disease and Stroke', Retrieved 7th February, from http://www.irishheart.ie/iopen24/-t-7_18.html

Jakicic, J. M., Winters, C., Lang, W., Wing, R. R. (1999), 'Effects of Intermittent Exercise and Use of Home Exercise Equipment on Adherence, Weight Loss, and Fitness in Overweight Women a Randomised Trial', *Journal of the American Medical Association,* Vol. 282, No. 16, pp. 1554 – 1560.

Jakicic, J. M., Wing R. R., Butler, B. A., Robertson, J. A. (1995), 'Prescribing Exercise in Multiple Short Bouts: Effects on Adherence, Cardiorespiratory Fitness and Weight Loss in Overweight Women', I*nternational Journal of Obesity,* Vol. 19, No. 12, pp. 893-901.

Johannes, L. (2009), 'How Accurate are Devices that Track Calories Used?', The Wall Street Journal, Vol. 253, No. 145, pp. 1- 2.

Kasabach, C., Pacione, C., Stivoric, J., Teller, A., Andre, D. (2002), 'Why the Upper Arm? Factors Contributing to the Design of an Accurate and Comfortable, Wearable Body Monitor', *BodyMedia Inc,* pp. 1 – 6.

King, A. C., Ahn, D. K., Oliveira, B. M., Atienza, A. A., Castro, C. M., Gardner, C. D. (2008), 'Promoting Physical Activity through Hand-Held Computer Technology', American *Journal of Preventive Medicine,* Vol. 34, No. 2, pp. 138-142.

Lauzon, N., Chan, C. B., Myers, A. M., Tudor-Locke, C. (2008), 'Participant Experiences in a Workplace Pedometer-Based Physical Activity Programme', *Journal of Physical Activity and Health,* Vol. 5, No. 5, pp. 675-687.

Lawerence, D., Shank, J. (1995), 'Health Care Diaries of Young Women', *Journal of Community Health Nursing,* Vol. 12, No. 3, pp. 171-182.

Liden, C. B., Wolowicz, M., Stivoric, J., Teller, A., Kasabach, C., Vishnubhatla, S., Pelletier, R., Farringdon, J., Boehmke, S. (2002), 'Characterisation and Implications of the Sensors Incorporated into the SenseWear Armband for Energy Expenditure and Activity Detection', *BodyMedia,* pp. 1-7.

Macfarlane, D. J., Lee, C. C. Y., Ho, E. Y. K., Chan, K. L., Chan, D. (2006), 'Convergent Validity of six methods to Assess Physical Activity in Daily Life', *Journal of Applied Physiology,* Vol. 101, No. 5, pp. 1328-1334.

Marcus, B. H., Emmons, K. M., Simkin- Silverman, L. R., Linnan, L. A., Taylor, E. R., Bock, B. C., Roberts, M. B., Rossi, J. S., Abrams, D. B. (1998), 'Evaluation of Motivationally Tailored vs Standard Self-help Physical Activity Interventions at the Workplace', American Journal of Health Promotion, Vol. 12, No. 4, pp. 246-253.

Merom, D., Riessel, C., Phongsavan, P., Smith, B. J., VanKemenade, C., Brown, W. J., Bauman, A. E. (2007), 'Promoting Walking with Pedometers in the Community, the Step by Step Trial', *American Journal of Preventive Medicine,* Vol. 32, No. 4, pp. 290-297.

Mutrie, N., Galloway, L., MacDonald, P., MacDonald, S. (2004), 'Will Pedometer Help People Maintain Walking Habit?', *Journal of Sports Science,* Vol. 23, No. 2, pp. 178-179.

Paffenbarger, R. S., Hyde, R. T., Wing, A. L., Lee, I. M., Jung, D. L., Kampert, J. B. (1993), 'The Association of Changes in Physical Activity Level and Other Lifestyle Characteristics with Mortality Among Men', *New England Journal of Medicine,* Vol. 328, No. 8, pp. 538 – 545.

Pate, R., Pratt, M., Blair, S., Haskell, W. L., Macera, C. A., Bouchard, C., Buchner, D., Ettinger, W., Heath, G. W., King, A.C. (1995), 'Physical Activity and Public Health: A Recommendation for the Centres for Disease Control and Prevention, and the American College of Sports Medicine', *Journal of the American Medical Association,* Vol. 273, No. 5, pp. 402 – 407.

Phillippaerts, R. M., Westerterp, K. R., Lefevre, J. (2001), 'Comparison of Two Questionnaires with a Tri-Axial Accelerometer to Assess Physical Activity Patterns', *International Journal of Sports Medicine,* Vol. 22, No1, pp. 34-39.

Robertson, J. K. (2004). Percieved Exertion for Practioners: Rating Effort with the OMNI Picture System. Champaign, IL: Human Kinetics

Sallis, J. F., Saelens, B. E. (2000), 'Assessment of Physical Activity by Self-Report: Status, Limitations and Future Directions', *Research Quarterly for Exercise and Sport,* Vol. 71, No. 2, pp. 1-14.

Sarkin, J. A., Nichols, J. F., Sallis, J. F., Calfas, K. J. (2000), 'Self-Report Measures and Protocols Affect Prevalence Estimates of Meeting Physical Activity Guidelines', *Medicine and Science in Sports and Exercise,* Vol. 32, No.1, pp. 149-156.

Schumann, A., Estabrooks, P. A., Nigg, C. R., & Hill, J. (2003), ' Validation of the Stages of Change with Mild, Moderate and Strenous Physical Activity Behaviour, Intentions, and Self-Efficacy', *International Journal of Sports Medicine,* Vol. 24, No. 5, pp. 363-365.

Slan Survey, (2007), 'Survey of Lifestyle, Attitudes and Nutrition in Ireland', *Department of Health and Children,* (2008), pp.1-152, Retrieved 7th November, from http://www.dohc.ie/publications/pdf/slan07_report.pdf?direct=1

Spiegal, M.R., Schiller, J., Srinivasan, R. A. (2008), 'Probability and Statistics', 3rd Edition, Schaums Outlines.

Steele, B. G., Belza, B., Cain, K., Warms, C., Coppersmith, J., Howard, J. (2003), 'Bodies in Motion: Monitoring Daily Activity and Exercise with Motion Sensors in People with Chronic Pulmonary Disease', *Journal of Rehabilitation Research and Development,* Vol. 40, No. 5, pp. 45-58.

Stovitz, S. D., VanWormer, J. J., Center, B. A., Bremer, K. L. (2005), 'Pedometers as a Means to Increase Ambulatory Activity for Patients seen at a Family Medicine Clinic', *The Journal of the American Board Family Practice,* Vol. 18, No. 5, pp. 335-343.

Taraldsen, K., Torunn, A., Olav, S., Kristin, E. E., Gruner, B. K., Bent, I., Laegdheim, H. J. (2011), 'Evaluation of a Body-Worn Sensor System to Measure Physical Activity in Older People', *Physical Therapy,* Vol. 91, No. 2, pp. 277-285.

Thurston, M., Green, K. (2004), 'Adherence to Exercise in Later Life: How Can Exercise on Prescription Programmes be Made More Effective', *Health Promotion International,* Vol. 19, No. 3, pp. 379-387.

Tudor-Locke, C. (2002), 'Taking Steps Towards Increased Physical Activity:Using Pedometer To Measure and Motivate', *Presidents Council on Physical Fitness and Sports, Research Digest,* Vol. 3, No. 17, pp. 1-8.

Tudor-Locke, C., Lutes, L. (2009), 'Why Do Pedometers Work? A Reflection upon the Factors Related to Successfully Increasing Physical Activity', *Sports Medicine,* Vol. 39, No. 12, pp. 981-993.

Tudor-Locke, C., Myers, A. M., Rodger, N. W. (2000), 'Formative Evaluation of the First Step Programme: A Practical Intervention to Increase Daily Physical Activity', *Canadian Journal of Diabetes,* Vol. 47, No. 1, pp. 23-28.

World Health Organisation. (2011), Global Recommendations on Physical Activity for Health, Retrieved November 7th, 2011, from http://www.who.int/dietphysicalactivity/physical-activity-recommendations-18-64years.pdf

World Health Organisation. (2011), Global Strategy on Diet, Physical Activity and Health: Physical Inactivity: A Global Public Health Problem, Retrieved 7th November 2011, from http://www.who.int/dietphysicalactivity/factsheet_inactivity/en/index.html

Yamanouchi, K., Shinozaki, T., Chikada, K. (1995), 'Daily Walking Combined with Diet Therapy is a Useful Means for Obese NIDDM Patients not Only to Reduce Body Weight but also to Improve Insulin Sensitivity', *Diabetes Care',* Vol. 18, No. 6, pp. 775-778.