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FINGER PHOTOPLETHYSMOGRAPH AS A MONITORING DEVICE FOR LIPID PROFILE IN MEN WITH CARDIOVASCULAR RISK.

[1]RAIFANA ROSA MOHD SATTAR, [2]KALAIVANI CHELLAPPAN, [3]NORSUHANA OMAR, [4]NORANITA MEGAT M N, [5]AMILIA A

[1]MSc. Student, Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
[2]Senior Lecturer, Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
[3]Phd. Student, Faculty of Medicine, Universiti Sains Malaysia
[4]Associate Professor, Faculty of Medicine, Universiti Kebangsaan Malaysia
[5]Lecturer, Faculty of Medicine, Universiti Kebangsaan Malaysia

E-mail: [1]raifana.rosa@gmail.com, [2]kckalai@ukm.edu.my, [3]noranitamn@gmail.com, [4]drnorsuhana@gmail.com, [5]amyyra1234@yahoo.com

ABSTRACT

Photoplethysmogram is a non-invasive optical technique that is widely used to measure the variation of blood volume by using infra-red light. It is a potential technique for early screening of atherosclerosis and lipid profiling. An intervention program of 12 weeks was done in monitoring the changes in lipid profile in the blood vessel and the morphological changes in the PPG signal. A total of 35 young men aged 20 to 40 years old were selected and the subjects were leading a sedentary lifestyle with less than 5000 steps of walking per day and having two or more CV risk factors. The subjects recruited were divided into two groups that were Group P (n=19) and Group C (n=16). Parameters that were recorded along the intervention were vascular age and fitness index (PPGF) from PPG, lipid profiling, pulse wave velocity (PWV), body mass index (BMI), waist circumference (WC), systolic blood pressure (SBP) and diastolic blood pressure (DBP). A first derivative of PPG was done in determining the crest time (CT). The data were recorded at three different stages, baseline, 6th week and 12th week. The morphological analysis clearly differentiates the subjects with different combination of lipid profiles. Results show that there is a significant improvement on PPGF and CT at the first 6 weeks whereas on the lipid profiling of TG, HDL and LDL shows consistent improvement throughout the 12 weeks' intervention. The intervention for health maintenance has potential in adopting walking as an exercise and PPG device as a health measurement tools. The identified morphological classification will need further analysis and automated classification to establish a non-invasive low cost optical based screening method for lipid profiling in future.

Keywords: *Photoplethysmogram, pedometer-based walking, Lipid Profile, Cardiovascular Risk, Young Men*

1. INTRODUCTION

The economic growth in Malaysia has been linked to ongoing lifestyle changes of urbanization including improper diets and reduced physical activity especially among young adults [1-3] Even though there are many different types of health management program and activities initiated by both government and NGO's, there are very limited responses from the public. The two main obstacles commonly highlighted by the public are the time factor and the effective health performance outcome measurement techniques. Therefore, CVD shows the leading cause of mortality and disability in health that lead towards death in both men and women [4]. The risks factors that contribute towards CVD are hypertension, diabetes, obesity, smoking and dyslipidaemia which influence the body and fitness among adults [5,6]. According to the National Cardiovascular Disease Database (NCVD) that dyslipidaemia is the second highest risks consume in adults with 55.9% [7] and contributes 4.5% of death of people in the world [8]. Moreover, the ratio of men having CVD risk to women is 3:1 higher than women [9]. Dyslipidaemia is one of the common factors among

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young men which contribute to plaque formation [10]. Plague is the formation of fat, cholesterol, calcium and other substances in the blood which leads to blood cloth and even by time the plaque can hardens and narrow the arteries. Thus this will limit the oxygenated blood from flowing to organs and other parts of the body [11]. Many different approaches have been adopted by both healthcare providers and researchers from various fields in identifying the walking as an exercise for the working adults and a non-invasive technique in monitoring lipid profile. Walking which has been a part of our daily life converted into a workout is one of the inexpensive and easily adopted methods proposed for working adults. As for identifying a good friendly health self-monitoring tool and technique, Photoplethysmogram is a noninvasive optical device that measure blood volume change at peripheral vessels. Hence, the changes in the blood volume can be analyze and observe through the PPG signal morphological analysis which give many information on the cardiovascular which had been discussed previously by many researchers. The PPG can be a potential marker in monitoring CVD risk. In this paper authors have adopted both pedometer and PPG technology as an approach in addressing the barriers faced by the working adult in monitoring their exercise activity by espouse walking as the exercise mode. Both the simple, low cost and operator independent technology expected to provide a user-friendly environment to encourage increasing working adult participate in championing walking as an exercise among Malaysian population in managing cardiovascular related diseases and risk factor as a part of the national agenda for people to experience an improving living condition.

1.1 Lipid Measurement Technique

Monitoring our lipid or cholesterol value is very important in maintaining a god health and an early prevention from having risk factors of cardiovascular disease. But in order to measures a lipid profile or cholesterol level, the technique that usually used in the clinic or hospital is more towards an invasive procedure and it is very time consuming in getting the results and finding the time to go to the clinic. Basically, a complete lipid profile test measures four types of lipid which are total cholesterol, low-density lipoprotein (LDL), high density lipoprotein (HDL) and triglyceride (TG). Before taking the test, fasting on food or beverages for nine to twelve hours before is necessary which it may affect the measurements of cholesterol.

The common procedure in clinics or hospital to measures lipid profile is blood sample is taken from the person and the blood sample will be taken to lab for test and measurements of lipid profile. There are several risks associated when blood is drawn for a cholesterol test which are feeling of slightly faint or having soreness or pain at the site where the blood was taken. Also there is also a slight risk of infection at the puncture site. The procedure in taking the test is invasive and frightening to some person which it may give the person an uncomfortable feeling. Thus these are the disadvantages of the current procedure now in measuring cholesterol level which may prevent in maintain or monitoring a person health. Furthermore, the time of going to the clinics in taking the test and the results produce in several days that gives big limitations for young men nowadays in maintaining their health.

Monitoring lipid profile level is very important in maintain a healthy lifestyle. Therefore, a non-invasive, practical and user friendly device is demand in overcoming the limitation of a person anxious and time consuming. Photoplethysmogram (PPG) device is a device that is non-invasive and non-painful that is to be proposed in this study. A PPG fitness had been established previously by Dr Kalaivani Chellappan through the PPG device can give a result calculating automatically the person vascular age, risk and fitness index. With the device that is user friendly and the information given that is easy for a person to understand, this may give early detection and prevention of risk factors of cardiovascular diseases.

1.2 Lipid Profile

Cholesterol is a waxy, fatty like substance found in all animal products [12]. The body can produce cholesterol in the liver and can absorb cholesterol from the diet. Cholesterol is a fat-like substance (lipid) that is present in cell membranes and is a precursor of bile acids and steroid hormones. Cholesterol travels through the blood stream in small packages called lipoproteins where the fats (lipid) are on the inside and proteins on the outside. The three major classes of lipoproteins found in the serum of a fasting individual are low density lipoproteins (LDL), high density lipoproteins

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(HDL) and very low density lipoproteins (VLDL) [13].

The role of LDL is where the cholesterol is transported to various body cells and stores excess cholesterol in the artery walls which may increase the risk of heart disease. When LDL cholesterol is exposed to a process called oxidation, the LDL cholesterol will go through and interact with the walls of artery creating a harmful inflammatory response. These processes will damage the arterial response and if the LDL cholesterol is in an excessive quantity, these can cause further injury to the target areas. Thus, high LDL cholesterol can cause plaque and leads to atherosclerosis where the LDL tends to be deposited in the artery walls and plaque will slowly grow and blocks the artery. Thus the blood flow is restricted through this narrowed blood vessel as shown in Figure 1. Hence these complications may lead to the increase risk of heart attack.

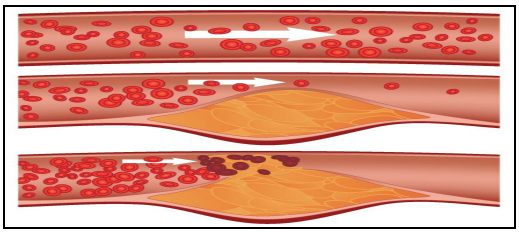

Figure 1: Process of Plaque Formation.

HDL is responsible for the delivery of cholesterol from the blood and artery walls to the liver which it then converted to bile to be used for body to digest food. The higher the HDL level, the lesser the chance of getting heart disease.[11]

A triglyceride is an ester derived from glycerol and three fatty acids and thus classified as a simple lipid. Adipose tissue in the body contains triglycerides and when the body uses adipose tissue as an energy source, the triglycerides react with water to release free fatty acids and into the blood [14]. Increased plasma TG is one of the metabolic risk factors that constitute the metabolic syndrome. Other risk factors include large waist circumference, low HDL, high blood pressure and elevated plasma glucose. An individual who has any of the three risk factors is considered to have metabolic syndrome [13].

TG interacts with the HDL cholesterol where HDL level decreases as the TG level increases. A high TG level is also associated with the inflammatory response and cause damage to the artery wall. These high TG may lead to blood clots that form and block the arteries, thus contributing in hardening of the artery wall such as in Figure 2. A high TG contributes to atherosclerosis and causes symptoms such as body pain, weakness and numbness. Atherosclerosis increases the risk factors of stroke, heart attack and heart disease [15]. The desirable level of lipid profile is as in Table 1 below.

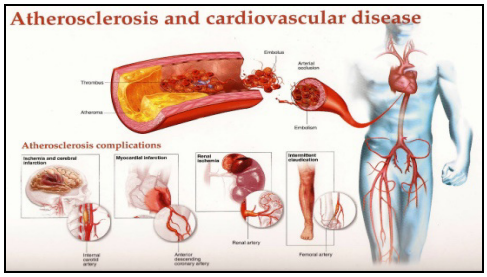

Figure 2: Atherosclerosis & Cardiovascular Disease.

Table 1: Level of Lipid Profile

Level Lipid Profile (mmol/L)	Good	Risk	Bad
Low Density Lipoprotein, LDL	2.6 – 3.34	3.36 – 4.19	Higher than 4.2
Triglyceride, TG	Less than 1.68	—	Higher than 1.7
High Density Lipoprotein, HDL	1.03 – 1.56	**Healthy** Higher than 1.56	Below than 1.04

1.3 Photoplethysmograph

Photoplethysmogram (PPG) which comes from a Greek word of *'plethysmos'* meaning increase [16,17] and *'graph'* means write [17] where this PPG device is mainly used for determining the variation in the blood flow in the body with each heartbeat in a wave like motion [18] where the sum of backscattered light corresponds with the variation of blood volume [19]. PPG pulse was first introduced by Hertzman in 1938 a simple method and device for measuring the relative blood volume changes in the vessels [20] The basic PPG sensor includes an infrared light LED and a photo detector built in a plastic casing. The sensor used can be either the transmitting type or the reflecting type.

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Some of the application of PPG are monitoring of heart and respiratory rates, assessment of venous function, measuring the ankle pressure, measuring genital responses, assessment of venous reflux, measuring cold sensitivity, measuring blood pressure and the assessment of cardiac output [19]. This area of research is expanding as the advantages of the non-invasive tool attract more researchers to do more diagnosis and discovering other methods in analyzing the signal for more PPG applications and to obtain the features from PPG signal.

The PPG device is also a convenient diagnostic tool since the detection can be easily detected at the tissue pads of the ear, finger and toes where the position of the blood vessel is near to the surface. The PPG waveform produced has a DC and AC component where the DC represents the blood volume changes and the AC shows the cardiac synchronous changes in the blood volume with each heartbeat as shown in Figure 3.

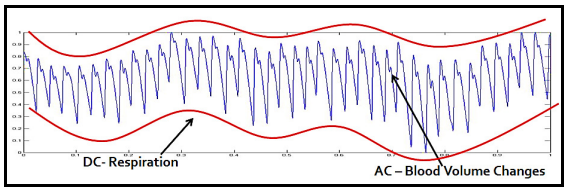

Figure 3: The AC and DC components in PPG waveform.

Arterial stiffness related changes in the pulse shape characteristics can also yield valuables information diagnosis on the CVD risk. A research in investigating the influence of age, gender, race, BMI, lipid profile and hemodynamic factors on arterial stiffness has been done [21]. Stiffness index (SI) and reflection index (RI) has been calculated by using statistical analysis and the results shows that the range of the normality of the arterial stiffness depends on the age, race, lipid profile, heartbeat and blood pressure of an individuals. It had been proved that the PPG pulse transit time changes with age.

Other research works also has been done by using the first and second derivatives of PPG (SDPPG) in studying the lipid level related indices and others more rick factors in detecting atherosclerotic vascular disease [22, 23]. Classification of CVD is one useful feature by calculating the crest time (CT) which is the time from the foot of the PPG waveform to its peak. As proven by Alty et al [24], by using the features extracted from the PPG signal they had developed a classification method of subjects into high and low pulse wave velocity which represents the high and low CVD risk. It is found that the peak to peak time, crest time and the stiffness index were the best features in classifying of CVD. They had tested several sets of these features for classification and they achieved a classification result of 87.5%.

Walking as an exercise is a good way and beneficial when performed regularly [22]. Evidence supports that even low to moderate intensity activities that performed daily can have long-term health benefits and lower the risk of CVD [26]. According to a report by C3 Collaborating for Health states that walking burns fat or plaque more than jogging [27].

Based on previous researches by researchers shows many application of PPG in interpreting the PPG signal related to blood volume and the arterial stiffness. However, there are no specific studies on classifying lipid profile value and the impact of walking or exercise on the PPG signal properties. With these correlations of PPG signal and lipid profile, the aim of the study is to show the different effect of PPG signals by observing at the PPG signal morphology between the subjects with different components of lipid profile. Intervention of promoting walking as exercise had been implemented. Hence to introduce finger photoplethysmograph as a monitoring device for lipid profile in men with cardiovascular risk.

2. METHODOLOGY

2.1 Subjects

A total number of 35 young males were selected randomly aged between 20 to 40 years old. The study was conducted in IKBN Hulu Langat. The criteria of the subjects selected were based on subjects with two or more cardiovascular risk factors which include dyslipidaemia, smoking, hypertension, obesity and the family history of having CVD.

The subjects that were selected currently undergoing a sedentary lifestyle with less than 5000 steps in casual walking per day. The study has obtained the ethical approval from PPUKM (FF-2014-139). The subjects had been explained on the purpose and procedures of the study and a consent form has been signed by each subject by meaning

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agreeing and they have committed in participating in the study. Subjects were divided randomly into two groups: Group P (n=19) which they received a pedometer for the pedometer intervention and Group C (n=16) where they kept their normal sedentary lifestyle.

As in Table 2 the age, BMI, waist circumference (WC) and theirs steps for the baseline phase were averagely the same between the two groups.

Table 2: BMI, WC and Steps at Baseline Phase.

GROUP PARAMETERS	P	C
AGE	27.53±6.61	26.81±8.04
BMI	27.11±5.50	24.31±4.39
WC	89.42±12.60	83.38±12.96
STEPS	4994.74 ±61.85	4984.06 ±23.48

2.2 Photoplethysmograph

PPG waveform was recorded in a controlled environment temperature of 20°C - 25°C where subjects were asked to fast for 8 hours before the measurement were taken. Upon arrival subjects were asked to rest for 15 minutes as to maintain subjects' heartbeat at their very best rest. The PPG signal were recorded in a supine position and the device was attached to the index finger left or right with their hand placed steadily. A NivariX-Med PPG device was used in recording the measurement. The recording took two minutes and the output of the transmitted PPG device was digitally sampled at a sampling rate of 275 Hz and with a resolution of 16bit [27]. An algorithm was established by K Chellappan a customized algorithm for the best 100 pulse will selected and calculated which will shows the PPG fitness index, vascular age and the vascular risk of each subjects [29].

In obtaining a more accurate recognition of the PPG waveform features and inflection points, signal processing was done and the first derivative (FDPPG) of PPG signal was used as introduced by Takazawa et al [30] as shown in Figure 4 (b).

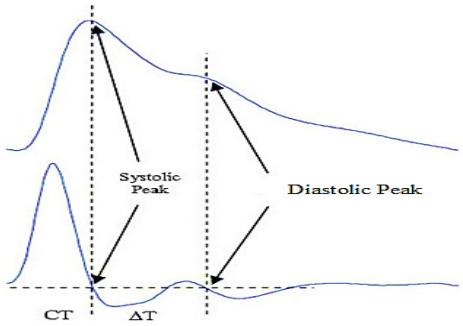

Figure 4: a) Original PPG waveform b) First Derivatives of PPG

3 RESULTS

Two analysis had been done in proving and strengthen the paper objectives. The first analysis was on visual observation which was focused on the LDL and TG and the second analysis was on the lipid profile (TG, LDL and HDL) in correlation with the PPGF and the crest time of FDPPG. High level of cholesterols is one of the critical component of lipid profiling that contributes towards early cardiovascular risk among young men [11].

3.1 Ppg Signal Visual Observation

The outcome has been categorized as stated in Appendix 1. The most significant component of lipid profiling components that has been identified in the PPG morphological analysis was LDL and TG. Subjects with high LDL and normal TG found to have consistent significant changes in the rising edge of the PPG waveform through graphical observation. Whereas subjects with high TG and normal LDL showed a shift in their first peak and changes in rising edge in comparison with the reference morphology. The last group which was high in both LDL and TG adopted both changes in previous group added with a significant budge after the first peak. Noted the earlier dicrotic notch and the higher second peak among the normal subjects are due to their sedentary lifestyle and other cardiovascular risk factors than has been included in this study such as smoking, obesity and hypertension (note: diabetic subjects were not included).

3.2 Statistical Analysis

Based on the results in Table 2, Body Mass Index (BMI), waist circumference (WC), blood pressure (SBP and DBP), pulse wave velocity (PWV), and

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lipid profile (TG, LDL, and HDL) were presented in mean and standard deviation for each group of pedometer (P) and control (C).

We observed that the BMI and WC had consistently reduced over the 6th and 12th weeks of the intervention for group pedometer. The subjects average BMI had decreased from 27.11±5.50 to 26.47±5.03. As for the subjects' WC from 89.42±12.6 cm had been reduced to 86.84±11.40 cm. However, for the control group, the subjects BMI and WC had no reduction and maintain the same or increased which was based on their daily activity for the day. As we can see that their BMI from 24.31±4.39 had increased to 24.44±4.34. Also for their WC from 83.38±12.96 cm had increased to 83.81±12.01cm.

Also for the blood pressure measurement for the pedometer group their SBP and DBP values were found to be reduced in the 6th week, SBP value of 119.58 ±8.80 and DBP value 66.32 ±9.02 and maintained along the 12th weeks, SBP value 119.47 ±8.65 and DBP value 66.21 ±8.86. PWV value also had decrease in the 6th weeks with value of 7.05±0.91 and the 12th week had been reduced to 6.53±1.02. As for the control group, the subjects blood pressure of SBP and DBP seem to be unstable with the values remain constant or increase during the intervention. Results show that the SBP value for the control group had decreased in the 6th week but increased in the 12th week. Moreover, for the DBP value in the 6th week the DBP value had increased but decreased in the 12th week.

For the lipid profile for group P, in LDL and TG level there is a significant devaluation and also in the HDL shows improvement during the intervention. For the subject's TG level from 2.00±1.25 had significantly reduced to 1.37±0.68 in the 12th weeks. Also for the LDL value shows from 3.32±0.89 had reduced to 3.05±0.91. But for the control group, the subject TG and LDL value seem to maintain around the same level throughout the intervention. There was not much difference in the lipid profile level during the intervention and their unstable level reduction or increased value were based on their daily activity for the day or week.

In PPGF for the pedometer group there was a noticeable change after the 6 weeks (60.99%±10.34) and some improvement in the 12 weeks (61.94%±7.79). As for crest time that was calculated using the first derivatives, at the 6th week there was changes in the CT value (0.2124±0.05288) and the value maintain constant at the 12th week (0.2134±0.04927). However, for the control group their PPGF shows unstable results from the 1st week of intervention (59.06% ±9.66), the 6th week (60.37% ±10.09) and at the 12th week (59.80%±8.88). The crest time for the C group remains constant throughout the 12 weeks.

Table 2: Parameters for Pedometer Group.

GROUP / PARAMETERS	PEDOMETER		
	B	**M**	**F**
BMI	27.11 ±5.50	26.84 ±5.45	26.47 ±5.03
WC	89.42 ±12.6	88.63 ±12.15	86.84 ±11.40
SBP	123.26 ±9.68	119.58 ±8.80	119.47 ±8.65
DBP	68.32 ±9.34	66.32 ±9.02	66.21 ±8.86
PWV	7.47 ±0.91	7.05 ±0.91	6.53 ±1.02
TG	2.00 ±1.25	1.63 ±1.17	1.37 ±0.68
LDL	3.32 ±0.89	3.37 ±0.76	3.05 ±0.91
HDL	1.00 ±0.00	1.11 ±0.32	1.21 ±0.42
PPGF	56.31 ±8.71	60.99 ±10.34	61.94 ±7.79
CREST TIME (CT)	0.23 ±0.04	0.21 ±0.05	0.21 ±0.05

Table 3: Parameters for Control Group.

GROUP / PARAMETERS	CONTROL		
	B	**M**	**F**
BMI	24.31 ±4.39	24.37 ±4.39	24.44 ±4.34
WC	83.38 ±12.96	84.00 ±13.01	83.81 ±12.01
SBP	122.06 ±5.76	120.37 ±9.87	120.81 ±9.52
DBP	67.38 ±7.34	68.94 ±9.62	68.50 ±9.77
PWV	7.25 ±0.78	7.31 ±1.19	7.31 ±1.01
TG	1.75 ±0.86	1.75 ±0.93	1.81 ±1.60
LDL	3.31 ±1.14	3.50 ±0.82	3.62 ±1.46
HDL	1.00 ±0.00	1.06 ±0.24	1.11 ±0.32
PPGF	59.06 ±9.66	60.37 ±10.09	59.80 ±8.88
CREST TIME (CT)	0.22 ±0.04	0.22 ±0.04	0.22 ±0.05

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4 DISCUSSION

The analysis was for visual observation was focused on Low Density Lipoprotein (LDL) and Triglyceride (TG) which is a critical component of lipid profiling that contributes towards early cardiovascular risk among young men [11]. The results had been categorized (appx). The observation on the visual appearance of the PPG signal was highlighted towards the systolic peak which is the first peak because this is when blood vessel is contracted because blood is exerted on the arteries and vessels while the heart is beating and the blood is transported throughout the whole human body system. At this peak, distortion in the PPG signal can be seen if the blood flow movement in the blood vessels is affected. Therefore, from the results of the visual observation it can be seen that subjects with high TG, the systolic peak shows a significant budge and shift on the time as compared to subjects with high LDL it can be seen only there were a budge at the systolic peak. The reason for subjects with high TG shows more noticeable changes because TG cholesterol basically is from the food we eat which is a simple lipid and it is used as energy for the body to work daily. However, when the body energy is not used in achieving its limit to burn the simple lipid in the body, the TG cholesterol will flow through the blood vessel and tends to deposited at the wall of the blood vessels or arteries and this may cause plaque in the future. Hence, the PPG signal produce will show distortion or budge at the systolic peak and the time for blood to flow will delayed which gives a shift the first peak. As for subject with high LDL, their PPG signal shows a budge at the systolic peak because LDL is a natural lipid that is produce by our body and is transported to several cells, thus if these lipid is not used as energy to the body, the excessive lipid will narrow the arteries or blood vessel and even block the blood vessel. Therefore, budge at the systolic peak was observed for subjects of high LDL only.

Next a more significant visual observation was for subjects with both high LDL and TG level which the PPG signal shows a shift and two or a wide budge at the systolic peak. The reason for this is the level of TG and LDL level in the blood is high, thus either the viscosity or the blood flow in the blood vessel is very limited. Which these shows atherosclerosis may happen and hence the blood flow in the blood vessels may take a longer time which can be seen in the shift of peak and the wide budge because of the limited space for blood to flow in the blood vessel or the high viscosity of blood in the blood vessels.

In the statistical analysis method, by regular exercise or even with just a consistent or a routine walking every day, the subjects' physical conditioning had improved where their heart rate and blood pressure decreases at rest and at given level of exercise. Since BMI and WC had been reduced and also the subjects blood pressure SBP and DBP together with their PWV for the pedometer group, the body ability to transport and deliver oxygen had improved, the subjects have added energy and less fatigue. This gives good improvement and benefits for subjects with CVD risk whose fitness is usually less than a healthy adult from their similar age.

In lipid profile for group P, in LDL and TG level there is a significant devaluation. We can conclude that by walking 8000 steps a day, a person can reduce the level of TG and LDL and even improve their HDL since the body has used the excessive bad lipids converted to energy for the body and produce more good lipid.

For the pedometer group, their PPG fitness and crest time shows improvement during the intervention. First derivatives from the PPG signal had been done to investigate more on the effect of lipid to the blood flow in the blood vessel. Crest time was calculated because as stated by Alty et al [23], crest time gives the best classification of CVD. Walking exercise had improved the indices of arterial stiffness and shows beneficial effect on the arterial stiffness condition. Although additional changes are not immediately respond to the stimuli in the walls of blood vessel. The blood vessels are trying to keep the structure as usual throughout the human body [31-33]. This gives great results which their body fitness and health seem to be increasing every day with a regular walking of 10,000 steps per day. These may give motivation for subjects to walk everyday by achieving the target without taking time to go to the park or gym as they can just count their steps by walking to the office or shops or going any place and still can maintain the health in good condition.

Based on the results from both analysis methods shows that there was an improvement on the lipid profile value and the PPG signal properties. It can be concluding that PPG can be a potential marker in monitoring CVD risk. Further studies are required for the investigation on the

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effect of walking exercise on the indices of arterial stiffness and wave reflection of PPG through a wider population intervention which includes urban, sub-urban and rural community. Female population study will be another aspect that need further attention by considering the working female responsibility in the selected community.

5 CONCLUSION

Non-invasive monitoring methods have become increasingly popular in the healthcare industries who consider various factors such as population growth, urban population and technological advances. In addition, the literacy rate is higher and rising awareness of health issues in Asian countries representing 60% of the world population needs to provide access to health information. Dyslipidaemia found to be a consistent cardiovascular factor but surreptitiously found increased among young men in developing countries. Long-term effects of these risks can lead to cardiovascular disease and stroke critical. One low-cost method of non-invasive examination is important in ensuring early detection, early diagnosis and early treatment to be taken into account. Effective automated method based on the findings above can potentially meet the requirements in creating a non-invasive lipid profiling. The proposed method is bind by the limitations in this study, firstly is the 12 weeks of intervention for subjects to keep track their 10,000 steps per day and keep their commitment in the intervention. Secondly, to analyse morphological properties of the PPG signal in relation to the lipid profile value.

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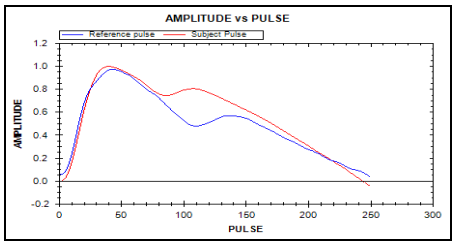
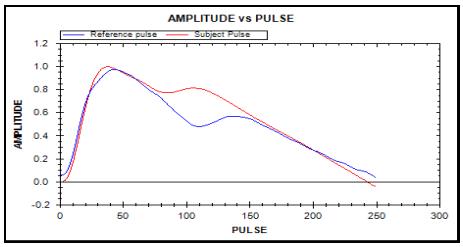
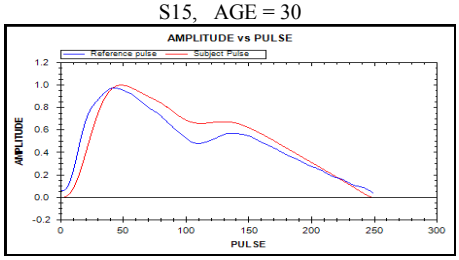
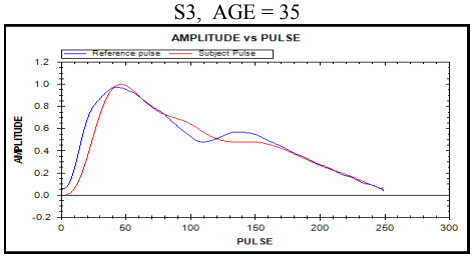
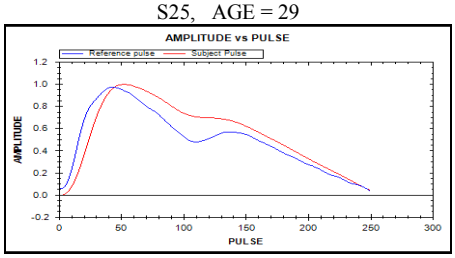
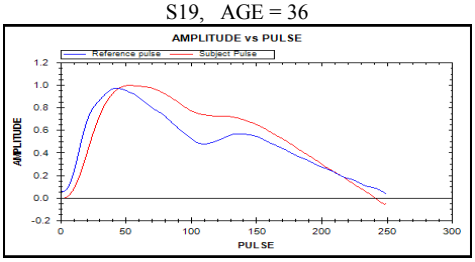
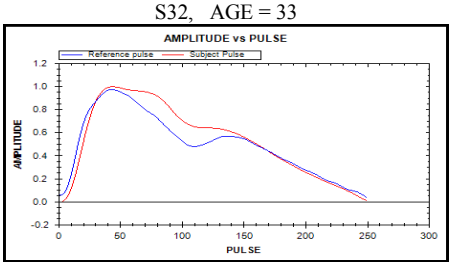
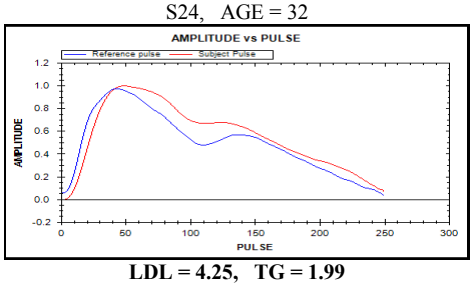
Appendix 1: PPG Waveform Morphological Properties versus Lipid Profiles

CONDITION	PPG WAVEFORM PROPERTIES AND LIPID PROFILES	
LDL normal, TG normal (mmol/L)	S63 AGE = 20  LDL = 1.91, TG = 0.8	S65 AGE = 20  LDL = 1.83, TG = 0.96
LDL high, TG normal	S15, AGE = 30  **LDL = 5.08,** TG = 1.32	S3, AGE = 35  **LDL = 4.8,** TG = 1.45
LDL normal, **TG high**	S25, AGE = 29  LDL = 3.28, **TG = 2.81**	S19, AGE = 36  LDL = 1.89, **TG = 2.25**
LDL high, TG high	S32, AGE = 33  **LDL = 3.53, TG = 2.0**	S24, AGE = 32  **LDL = 4.25, TG = 1.99**