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Designing Excel-VBA Program for the Analysis of Force-Time Curve Profile

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Abstract

This paper presents a novel Excel-Visual basic for application (VBA) program that simplifies the process for sport-science students and researchers dealing with Bertec force plate form outputs, without the need for knowing any programming language or using sophisticated-expensive software programs. The designed program automatically facilitates the following tasks: starting from reading, decoding, importing, graphing, extracting, calculating, reporting and finally archiving force–time variables measured by faceplate form to an Excel spreadsheet file. The imported input variables extracted from force plate text file are: serial numbers, time, ground reaction forces in three dimension (Fx, Fy, Fz), that help in creating the calculated force-time variables in an excel report sheet including: sampling frequency, start and end time, time range of ground reaction forces in three dimensions; the maxima, minima, time and duration of both extremes, in addition to the total impulses, both positive, and negative, with their time ranges.

Keywords: *Excel-VBA program, force-time curve, force plate form, spreadsheet, Dynamic chart*

Introduction:

The main objective of this paper is to design Excel-Visual basic for application (VBA) program that can be utilized by sport-science students and researchers for movement analysis when using Bertec force plate form outputs. Although other commercially software programs for movement analysis are available, but most of them are not affordable .In addition, they require extra costs for adding more features or updating the licensed program (Ibrahim, 2009). Also, the commercial software may need engineering and programming background to use them (Wong & Barford, 2010). Therefore the researcher finds that it is vital to design a free Excel-VBA software program that automatically simplifies the analysis processes. A program that can read, decode, import, graph, extract, calculate, report and archive force –time variables measured by faceplate form to an Excel spreadsheet file (Alexander & Walkenbach, 2012; Moffat, 2011; Morgado, 2016; Reding & Wermers, 2012; Walkenbach, 2013).

Abbreviates and scientific terms

Serial: consecutive numbers, each represents sample number starts from 0 to the last sample of data

Time: consecutive incremental time by 1/ force plate sampling frequency (s)

Fx: the medio-lateral component of Ground reaction force (N)

Fy: the antero-posterior component of Ground reaction force (N)

Fz: the vertical component of Ground reaction force (N)

Max: maximum value

Min: minimum value

Total impulse: is the area under force -time curve

Total positive impulse: is the area under force- time curve when force value is positive

Total Negative impulse: is the area under force- time curve when force value is Negative

Time to reach: the time from start to reach specific event (ex. time to reach Max Fx)

Time range of =the sum of the difference in time, between the start and end of specific event

Frequency=1/time difference between two consecutive faceplate time stamp

Sampling frequency is the number of samples of force data recorded per second

Area of a trapezoid: is given by (average height of a trapezoid) x (trapezoid base)

Trapezoid rule: an equation that uses the sum of trapezoids to represent the area under a curve (integral).

TI_Fx(total impulse in Fx): area under Fx-time curve using trapezoid rule (N.s)

SI_Fx(segmental impulse in Fx): segmental integration of Fx-time curve using trapezoid rule (N.s)

SI_pos_Fx(positive impulse in Fx): segmental integration of the area under Fx- time curve when Fx value is positive using trapezoid rule (N.s)

SI_ng_Fx(Negative impulse in Fx): segmental integration of the area under Fx- time curve when Fx value is negative using trapezoid rule (N.s)

TI_Fy(total impulse in Fy): area under Fy-time curve using trapezoid rule (N.s)

SI_Fy(segmental impulse in Fy): segmental integration of Fy-time curve using trapezoid rule (N.s)

SI_pos_Fy(positive impulse in Fy): segmental integration of the area under Fy- time curve when Fy value is positive using trapezoid rule (N.s)

SI_ng_Fy(Negative impulse in Fy): segmental integration of the area under Fy- time curve when Fy value is negative using trapezoid rule (N.s)

TI_Fz(total impulse in Fz): area under Fz-time curve using trapezoid rule (N.s)

SI_Fz(segmental impulse in Fz): segmental integration of Fz-time curve using trapezoid rule (N.s)

SI_pos_Fz(positive impulse in Fz): segmental integration of the area under Fz- time curve when Fz value is positive using trapezoid rule (N.s)

SI_ng_Fz(Negative impulse in Fz):): segmental integration of the area under Fz- time curve when Fz value is negative using trapezoid rule (N.s)(Liengme, 2016; Mizuguchi, 2012).

Methods

In the current study Microsoft Excel 2010 along with Visual Basic for Applications version.7 are used to manipulate ground reaction forces measured by force platform (MP4060®, Bertec Corporation, Columbus, OH, USA) at a sampling rate of 1000 Hz during the takeoff phase of single leg horizontal jumping. The measured signals from strain gauge based force transducers are amplified, filtered, and digitized in the force plate, which minimizes signal degradation due to external noise sources during analog signal transportation. Six squash players (age: 15 ±0.3 years old; height 1.50±0.15 m; mass: 45.56±1.23 Kg), played in the National Egyptian team, participated in this study. The parental consent of all players was obtained and the study was approved by the institutional ethics committee of studies and researches. The data collection period started with a dynamic warm-up for 10 minutes. Then, the participants were asked to stand on both legs in front of the force plate and each subject was instructed to take a step over the middle of the force plate with one foot and explosively jump as far forward as possible and land on the other foot . This task mimics a movement pattern which is frequently used in racket sports such as squash, badminton and fencing (Kuntze, 2010; Nadzalan et al., 2017; Phomsoupha & Laffaye, 2015; Williams & Kuitunen, 2010). Three trials were performed by each subject. The active rest between the three jumping trials was 4 minutes of walking. The third trial for each subject was chosen for analysis to waive the learning effect. The three ground reaction forces were measured using the force plate and saved in a text file. The vertical ground reaction force was normalized to subject body weight. Then, the designed Excel-VBA program was used to analyze force-time profile of the best horizontal jump ability of the six players.

Description of Excel-VBA software program

Excel-VBA software program has four main steps:

Step 1.Importing new data

The force plate form output file is a text file which is a different file format from Microsoft Excel 2010 workbook; therefore, it is essential to have a software program that will read, decode, and import five variables (serial, time, Fx, Fy, and Fz.) from this text file to an Excel workbook file. This will eliminate alternative complex manual approaches (Ozkaya, 1996). By clicking on the import new data control button in figure 1, it will activate VBA module called step1_1 which calls import and name_row ranges macros as shown in Appendix 1. The import macro deletes any old raw data in sheet1 and popup a Getopenfilename dialog box to choose the imported file name as shown in figure 2 while name_row ranges macro is used to dynamically chart imported raw data forces in three dimensions versus time as shown in figure 3.

The graphical representation of the force versus time data will help to understand the force- time profiles and will ease the selection of certain events and phases (Lim, Kim, Kim, & Han, 2017; Torres & Pedrini, 2016) . For example the force-time curve in the anterior-posterior direction can be used to identify the transition between braking and propulsive impulses(Marasovic, Cecic, & Zanchi, 2009; Peterson, Neptune, & Kautz, 2011); Subsequently, the force-time curve in the medio-lateral direction can be used to identify the transition between medial and lateral impulses (Wagner et al., 2017). In the same way, the force-time curve in the vertical direction can be used to, identify the impact peak, and the transition between negative and positive vertical impulses(Marasovic et al., 2009; Nordin, Dufek, & Mercer, 2017).

Figure (1)
Excel-VBA program starting window

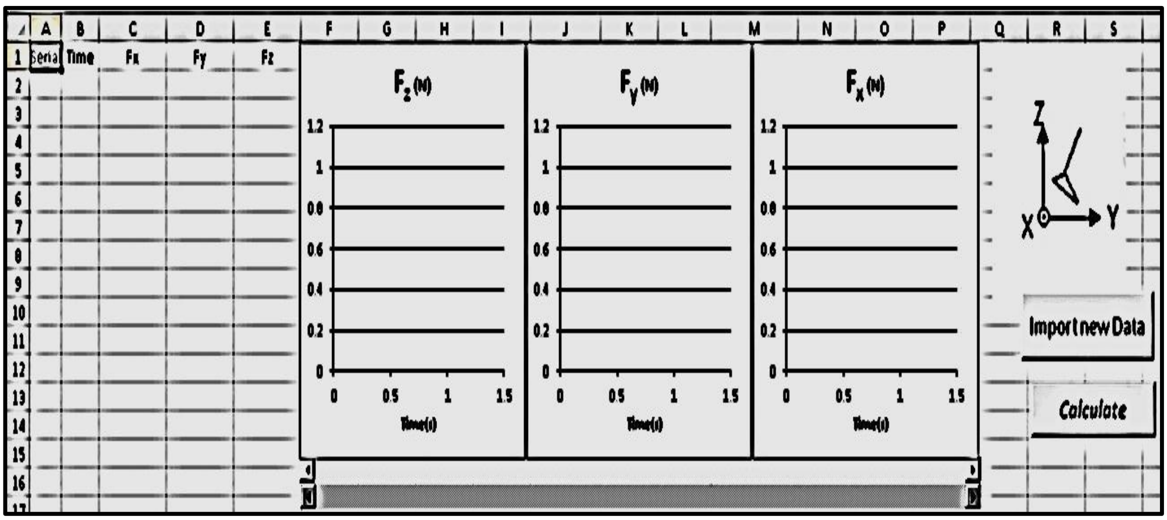


Figure (2)
Getopenfilename dialog box to choose the imported text file name

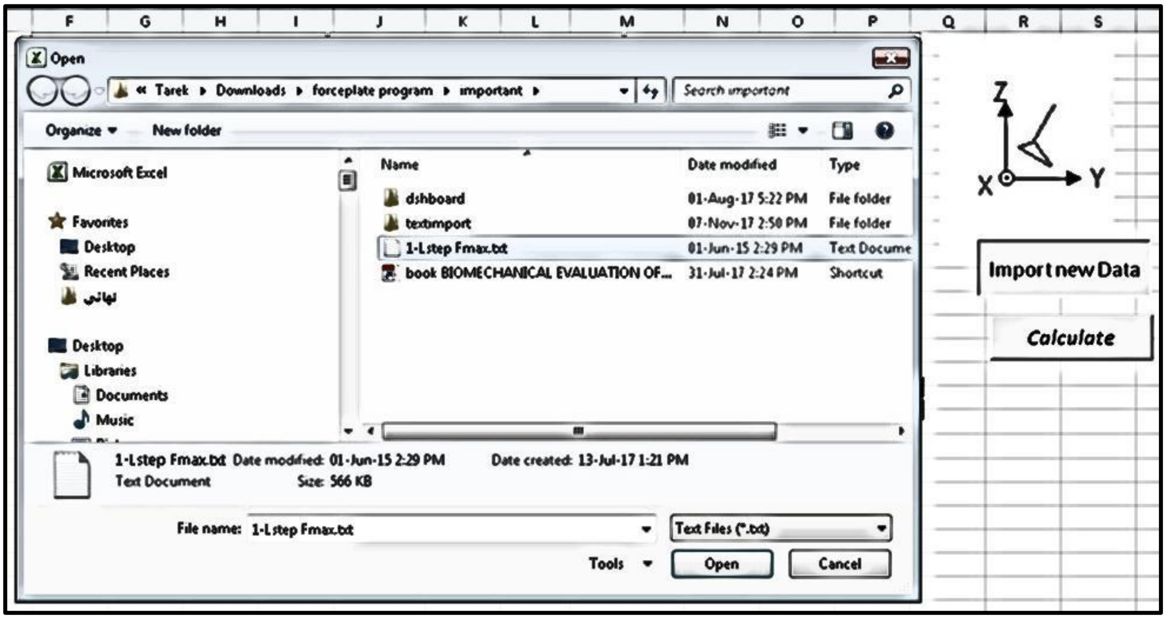
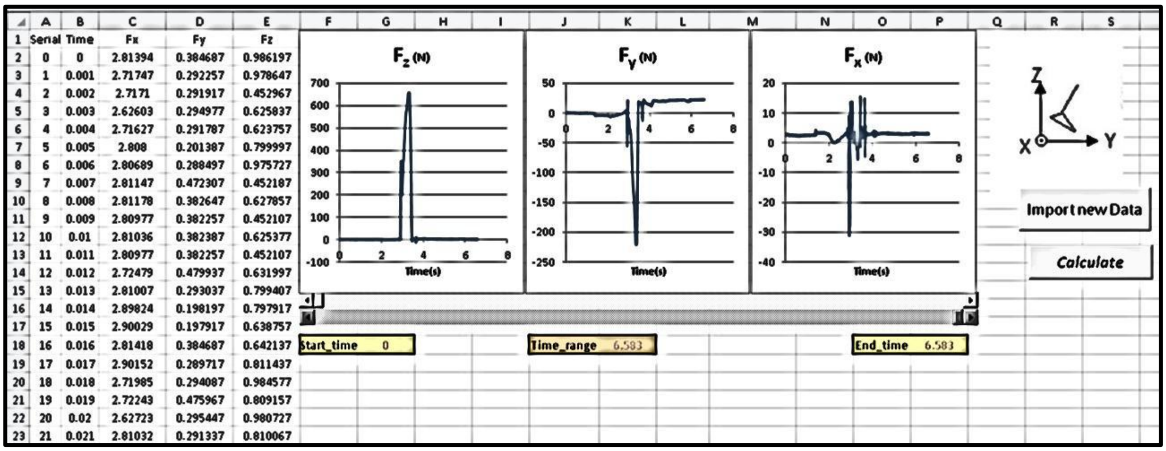


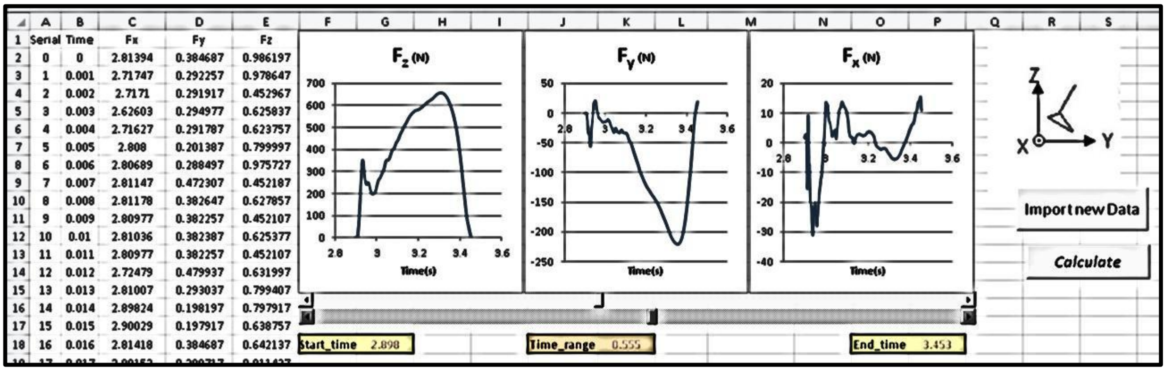
Figure (3)
Tabulated and dynamic chart representation of imported raw data



Step 2: Choosing the start and end time range for force-time analysis

Two horizontal sliding control bars are used to define the start and end time range for force-time analysis as shown in figure 4. The upper sliding control bar defines the start, while the lower one defines the end of time range of the three synched force-time curves, in three dimensions, in the same time. In the current study, take off phase of the horizontal jump was selected as shown in figure 4.

Figure (4)
Choosing the start and end time range for analysis using two horizontal sliding control bars



Step 3: Calculating force-time variables in sheet 2 and displaying final report in sheet3

By clicking on the Calculate control button in figure 4, it will activate VBA module called step1_2 as shown in Appendix 1 ; This module deletes any old data in sheet2, copy selected force-time data from sheet1 to sheet2, calculate force-time variables shown in table 1 & table 2, present the final report that contains calculated force-time variables in sheet3 (Table 2) along with graphical representation of the selected force-time curves in three dimension as shown in figure (5).

Table (1)
Calculated variables in sheet2

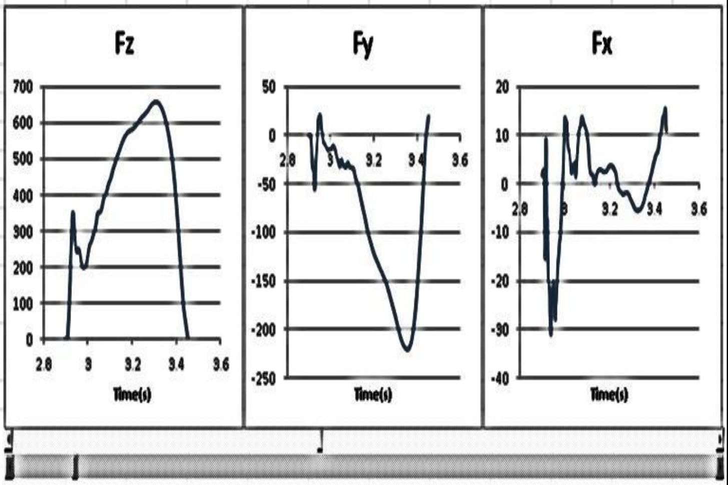
Excel Column naming	Variables	Calculated formulas
A	Serial	
B	Time	
C	Fx(Mediolateral force)	
D	Fy(anteroposterior force)	
E	Fz(vertical force)	
F	TI_Fx(total impulse in Fx)	=IF(ROW()=2,(ABS(($B$3-$B$2)*(C2+C3)/2)),IF(ROW()<=COUNT(C:C),((F1)+(ABS(($B$3-$B$2)*(C2+C3)/2))),""))
G	SI_Fx(segmental impulse in Fx)	=IF(ROW()<=COUNT(C:C),ABS(($B$3-$B$2)*(C2+C3)/2),"")
H	SI_pos_Fx(positive impulse in Fx)	=IF(AND(C2>=0, ROW()<=COUNT(C:C)),G2,"")
I	SI_ng_Fx(Negative impulse in Fx)	=IF(AND(C2<=0, ROW()<=COUNT(C:C)),G2,"")
J	TI_Fy(total impulse in Fy)	=IF(ROW()=2,(ABS(($B$3-$B$2)*(D2+D3)/2)),IF(ROW()<=COUNT(D:D),((J1)+(ABS(($B$3-$B$2)*(D2+D3)/2))),""))
K	SI_Fy(segmental impulse in Fy)	=IF(ROW()<=COUNT(D:D),ABS(($B$3-$B$2)*(D2+D3)/2),"")
L	SI_pos_Fy(positive impulse in Fy)	=IF(AND(D2>=0, ROW()<=COUNT(D:D)),K2,"")
M	SI_ng_Fy(Negative impulse in Fy)	=IF(AND(D2<=0, ROW()<=COUNT(D:D)),K2,"")
N	TI_Fz(total impulse in Fz)	=IF(ROW()=2,(ABS(($B$3-$B$2)*(E2+E3)/2)),IF(ROW()<=COUNT(E:E),((N1)+(ABS(($B$3-$B$2)*(E2+E3)/2))),""))
O	SI_Fz(segmental impulse in Fz)	=IF(ROW()<=COUNT(E:E),ABS(($B$3-$B$2)*(E2+E3)/2),"")
P	SI_pos_Fz(positive impulse in Fz)	=IF(AND(E2>=0, ROW()<=COUNT(E:E)),O2,"")
Q	SI_ng_Fz(Negative impulse in Fz)	=IF(AND(E2<=0, ROW()<=COUNT(E:E)),O2,"")

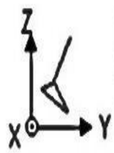
Table (2)
Calculated variables and their formulas in sheet3 (final report)

Calculated variables	Calculated formulas
Max Fx	=MAX(sheet2!$C:$C)
Min Fx	=MIN(sheet2!$C:$C)
Max Fy	=MAX(sheet2!$D:$D)
Min Fy	=MIN(sheet2!$D:$D)
Max Fz	=MAX(sheet2!$E:$E)
Min Fz	=MIN(sheet2!$E:$E)
Total Impulse Fx	=MAX(sheet2!$F:$F)
Total Postive Impulse Fx	=SUM(sheet2!$H:$H)
Total Negative Impulse Fx	=SUM(sheet2!$I:$I)
Total Impulse Fy	=MAX(sheet2!$J:$J)
Total Postive Impulse Fy	=SUM(sheet2!$L:$L)
Total Negative Impulse Fy	=SUM(sheet2!$M:$M)
Total Impulse Fz	=MAX(sheet2!$N:$N)
Total Postive Impulse Fz	=SUM(sheet2!$P:$P)
Total Negative Impulse Fz	=SUM(sheet2!$Q:$Q)
Frequency	=sheet2!$B$3-sheet2!$B$2
start time	=sheet2!$B$2
end time	=MAX(sheet2!$B:$B)
time range(end time - start time)	=MAX(sheet2!$B:$B)-sheet2!$B$2
Time of Max Fx	=INDEX(sheet2!$B:$B,MATCH(MAX(sheet2!$C:$C),sheet2!$C:$C,0))
Time of Min Fx	=INDEX(sheet2!$B:$B,MATCH(MIN(sheet2!$C:$C),sheet2!$C:$C,0))
Time of Max Fy	=INDEX(sheet2!$B:$B,MATCH(MAX(sheet2!$D:$D),sheet2!$D:$D,0))
Time of Min Fy	=INDEX(sheet2!$B:$B,MATCH(MIN(sheet2!$D:$D),sheet2!$D:$D,0))
Time of Max Fz	=INDEX(sheet2!$B:$B,MATCH(MAX(sheet2!$E:$E),sheet2!$E:$E,0))
Time of Min Fz	=INDEX(sheet2!$B:$B,MATCH(MIN(sheet2!$E:$E),sheet2!$E:$E,0))
Time to reach Max Fx	=INDEX(sheet2!$B:$B,MATCH(MAX(sheet2!$C:$C),sheet2!$C:$C,0))-sheet2!$B$2
Time to reach Min Fx	=INDEX(sheet2!$B:$B,MATCH(MIN(sheet2!$C:$C),sheet2!$C:$C,0))-sheet2!$B$2
Time to reach Max Fy	=INDEX(sheet2!$B:$B,MATCH(MAX(sheet2!$D:$D),sheet2!$D:$D,0))-sheet2!$B$2
Time to reach Min Fy	=INDEX(sheet2!$B:$B,MATCH(MIN(sheet2!$D:$D),sheet2!$D:$D,0))-sheet2!$B$2
Time to reach Max Fz	=INDEX(sheet2!$B:$B,MATCH(MAX(sheet2!$E:$E),sheet2!$E:$E,0))-sheet2!$B$2
Time to reach Min Fz	=INDEX(sheet2!$B:$B,MATCH(MIN(sheet2!$E:$E),sheet2!$E:$E,0))-sheet2!$B$2
Time range of Total Impulse Fx	=COUNT(sheet2!$G:$G)* (sheet2!$B$3-sheet2!$B$2)
Total Postive Impulse Fx	=COUNT(sheet2!$H:$H)* (sheet2!$B$3-sheet2!$B$2)
Time range of Total Negative Impulse Fx	=COUNT(sheet2!$I:$I)*(sheet2!$B$3-sheet2!$B$2)
Time range of Total Impulse Fy	=COUNT(sheet2!$K:$K)* (sheet2!$B$3-sheet2!$B$2)
Time range of Total Postive Impulse Fy	=COUNT(sheet2!$L:$L)* (sheet2!$B$3-sheet2!$B$2)
Time range of Total Negative Impulse Fy	=COUNT(sheet2!$M:$M)* (sheet2!$B$3-sheet2!$B$2)
Time range of Total Impulse Fz	=COUNT(sheet2!$O:$O)* (sheet2!$B$3-sheet2!$B$2)
Time range of Total Postive Impulse Fz	=COUNT(sheet2!$P:$P)* (sheet2!$B$3-sheet2!$B$2)
Time range of Total Negative Impulse Fz	=COUNT(sheet2!$Q:$Q)* (sheet2!$B$3-sheet2!$B$2)

Figure (5)
Final Report.

Calculated Variables		Time	Time to reach	Time range
Max Fx	15.52	3.448	0.55	
Min Fx	-31.0815	2.938	0.04	
Max Fy	20.8638	2.95	0.052	
Min Fy	-220.829	3.355	0.457	
Max Fz	657.874	3.306	0.408	
Min Fz	0.436137	2.908	0.01	
Total Impulse Fx	3.688984305			0.555
Total Postive Impulse Fx	1.92062956			0.337
Total Negative Impulse Fx	1.768354745			0.218
Total Impulse Fy	51.01207672			0.555
Total Postive Impulse Fy	0.408306638			0.04
Total Negative Impulse Fy	50.60377008			0.515
Total Impulse Fz	236.3712991			0.555
Total Postive Impulse Fz	236.3712991			0.555
Total Negative Impulse Fz	0			0
frequency	0.001			
start time	2.898			
end time	3.453			
time range(end time - start time)	0.555			





Step 4: saving all the workbook sheets as a workbook file for further analysis.

All workbook sheets are saved by clicking file save as button from the main menu and naming the workbook with a special name (subject name_ trial number). The saved files can be used to compare between different trials and subjects.

Conclusion

The Excel-VBA program provides the capability to rapidly, and automatically- without the need for knowledge of programming language or using any sophisticated-expensive software- to read, decode, import, graph, extract, calculate, report and archive force –time variables measured by force platform to an Excel spreadsheet file.

The main limitation of this study was that the program is designed for interfacing with force platform (MP4060®, Bertec Corporation, Columbus, OH, USA). Further studies need to be done using another type of force plate such as commonly used AMTI force plate.

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