The International Journal of Engineering and Science (IJES)
|| Volume || 7 || Issue || 5 Ver. III || Pages || PP 01-10 || 2018 ||
ISSN (e): 2319 – 1813 ISSN (p): 23-19 – 1805

Study Vibrations, Stresses and Stability of the Replacement Knee Joints and Comparison with the Healthy Case.

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-ABSTRACT-

Many patients are suffering from big medical problems at knee joint, this leads to total knee replacement surgery. This work give a study, measure and analyze to the muscular activity in patient's leg and heart, and vibration parameters .Also, this work investigates acceleration, frequency, which will measured at foot and knee joint in the patient leg for artificial replacement knee with different damping shoes. This patient is of age, weight, length and leg length of 56 years, 101 Kg, 170 cm and 99 cm, respectively. Results shows that the maximum reduction in acceleration at foot and knee joint were recorded when using athletic shoes+ ground air with (54.11 %). While, the frequency results showed that the maximum reduction was recorded when using the athletic shoes+ ground air + silicon damping with (40.3%).

KEYWORDS *- knee replacement, vibration, frequency, foot, acceleration.*

Date of Submission: 12-05-2018 Date of acceptance: 28-05-2018

I INTRODUCTION

A large synovial joint in the body and one the most complex biomechanical system known is the knee joint. The aim of synovial joints, also known as diarthroses, is to allow movement, supports flexion and rotation, raising complete stability and control under large variety of the knee allows the bearing of tremendous loads, as well as the mobility required for locomotor activities .There are four main bones that the knee composed of — the femur or thigh bone, the tibia or shin bone, the fibula or outer skin bone and patella or knee cap [1]. Moreover, knee joint consist of the tibiofemoral joint, and patellofemoral joint. The tibiofemoral joint a condyloid joint between the condyles of the femur and tibia. The tibiofemoral joint offers transmission of body weight from femur to the tibia, permitting a rotation along with a little degree of tibial axial rotation.These joints function together. Primarily as a modified hinge joint because of the restricting ligaments, with some lateral and rotational motions allowed. The patellofemoral joint that it is between posterior surface of the patella and the patellar surface of the femur [2]. Allows along with the tibialis anterior and ankle joint support the body to start the gait cycle [3].The patellofemoral joint involves of the articulation of the triangularly shaped patella, enclosed in the patellar tendon, with the trochlear groove between the femoral condyles [4].

There are different reasons caused a damage in knee joint such as: Osteoarthritis Years of normal practice can cause cartilage to crack and wear away (osteoarthritis). As uncovered bones rub together, they become rough and pitted. The joint grinds. Being overweight or having an alignment problem, such as knocked or bowed knees, puts extra force on the joint. This may get faster the damage. Inflammatory Arthritis a chronic disease, such as rheumatoid arthritis or gout, can cause swelling and heat (inflammation) in the joint lining. As the disease growths, cartilage may be worn away and the joint may harden.

Injury is a bad fall or shock to the knee can injure the joint. If the injury does not rebuild properly, extra force may be located on the joint. This can reason the cartilage to wear away (traumatic arthritis) [5]. The purpose of an artificial knee joint is to relieve pain, improve the function of your knee, improve your ability to move around and improve your quality of life [5].

An operation to replace the worn or damaged and diseased parts of your knee joint is called total knee replacement as shown in fig (1) [6].

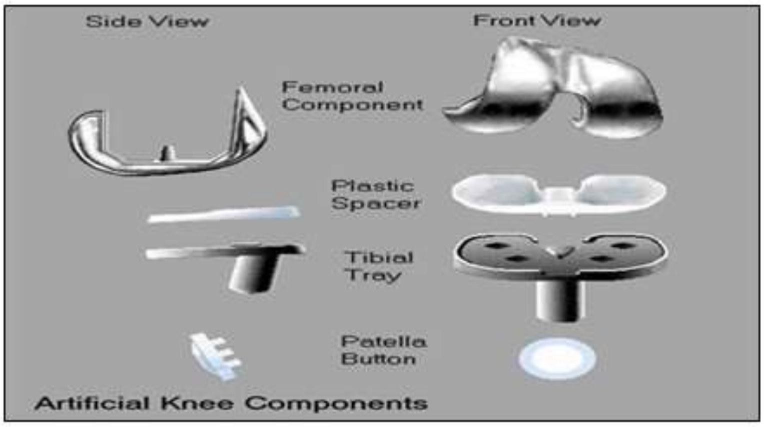


Figure (1): total knee replacement.

The vibration problems and stability will be studied and analyzed in order to reduce the effects using different types of shoes with different damping techniques.

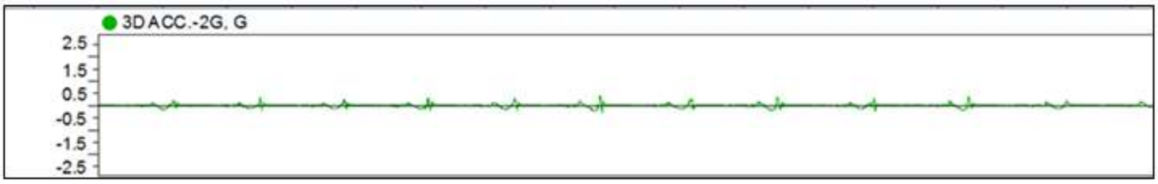
2- Experimental Procedure

The idea of the vibration and acceleration measurement system was a patient with replace artificial knee is measure when the accelerometer is firmly fixed on different points on the patient leg parts fig (2). This patient is of age, weight, length and leg length of 56years,75kg,165cm and 98 cm respectively .The data is transmitted to a computer using a Nor axon U.S.A. Inc. • 13430 N. Scottsdale Rd., Suite 104 • Scottsdale, AZ 85254. This measuring system is used to get various parameters such as (acceleration, frequency).

Figure (2): The vibration and acceleration measurement system using a Noraxon USA Inc. Scottsdale Rd.

II RESULTS AND DISCUSSION

Figure (1), figure (2), shows the acceleration data for foot and knee joints respectively when using different type of damping foot. These results are rearranging in table (1) and table (2) which shows that the level of acceleration at ankle joint is higher than knee joint this due to the fact that the foot is the first part faced the ground impact during gait cycle .These rustles shows that the maximum acceleration in foot is recorded when using Athletic shoes +ground air + silicon damping with value of 0.58 (N\m2) in Y-direction. Also the maximum acceleration in knee joint is recorded when using Athletic shoes + ground air with value of 0.32 (N\m2) in Y-direction. Also results shows that the maximum reduction in acceleration is recorded when using Athletic shoes + ground air with percent of 54%.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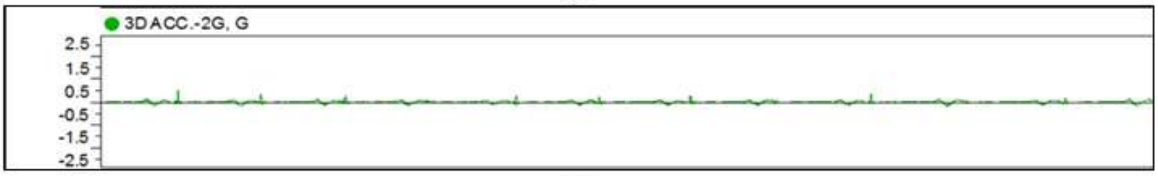
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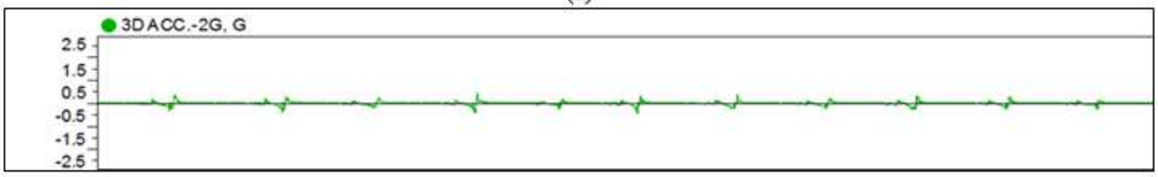
Z

(a)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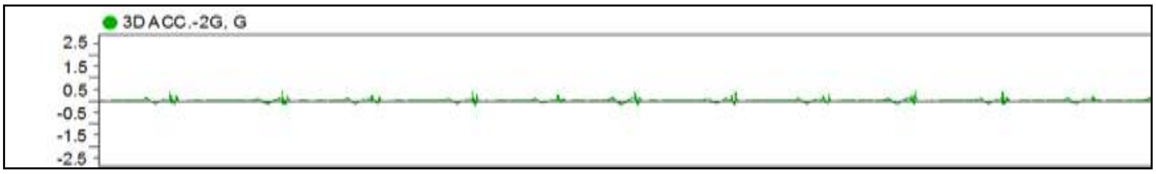
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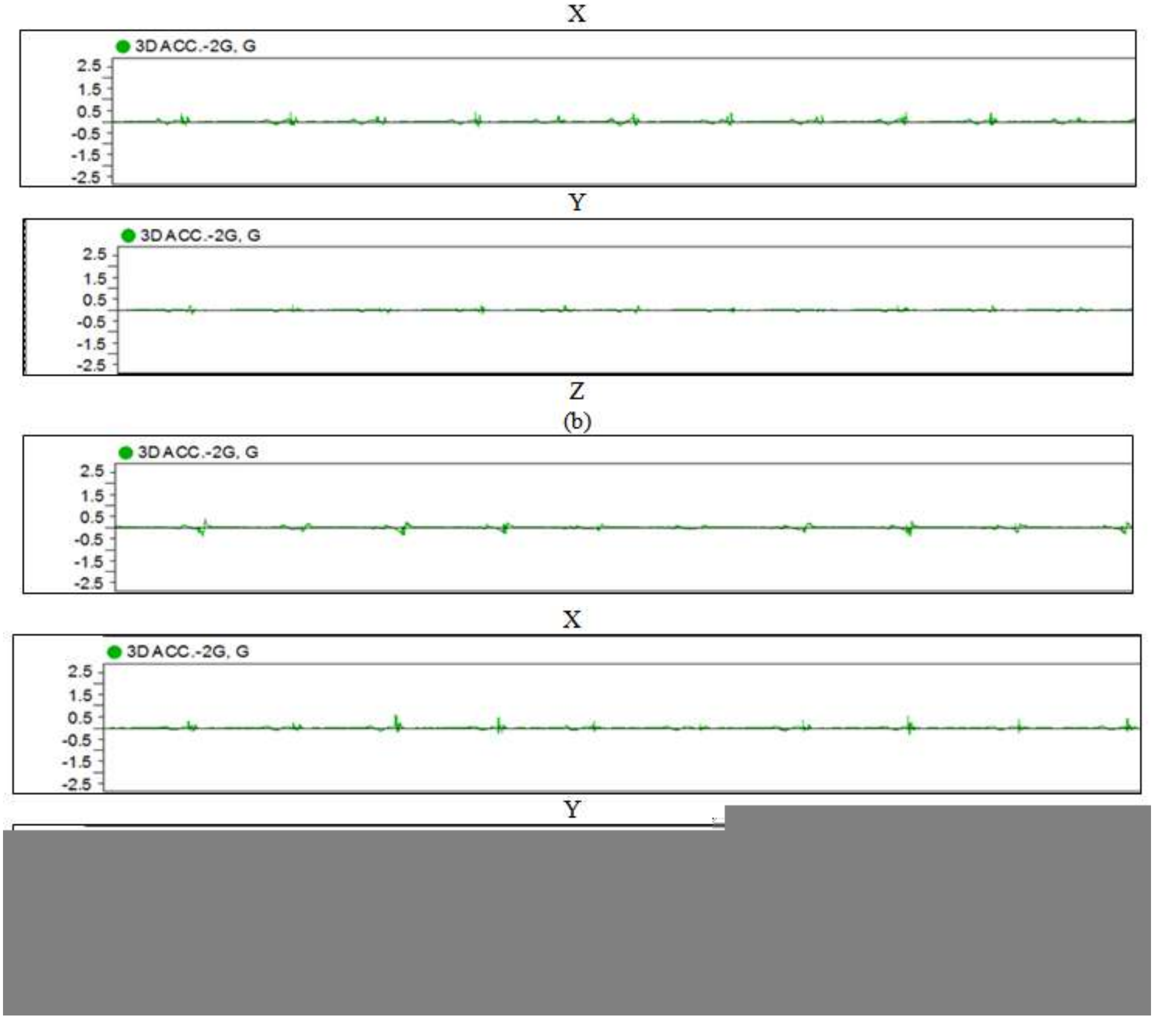
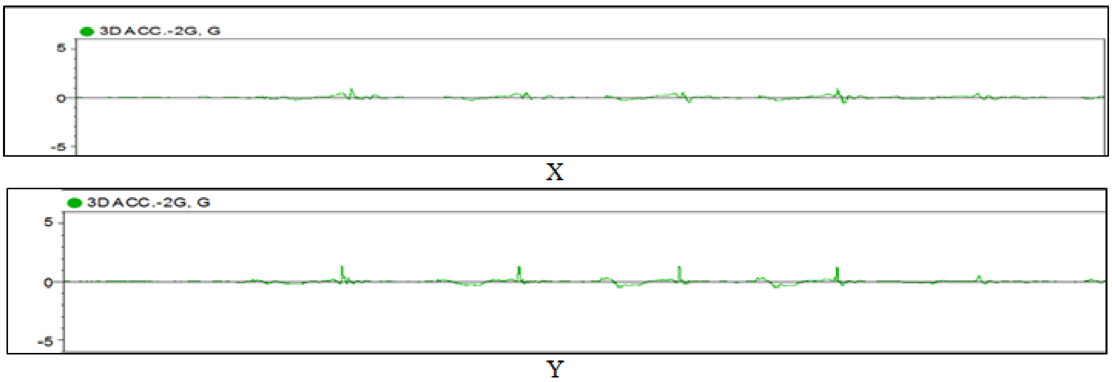
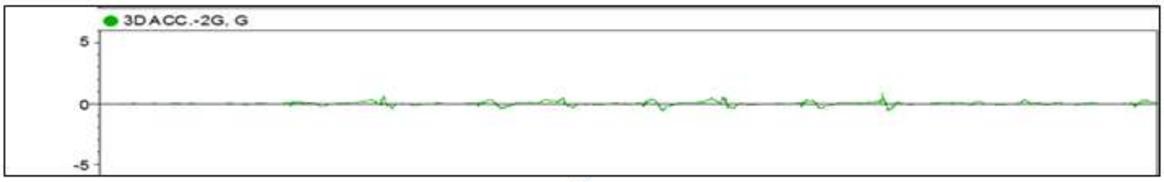


(c)

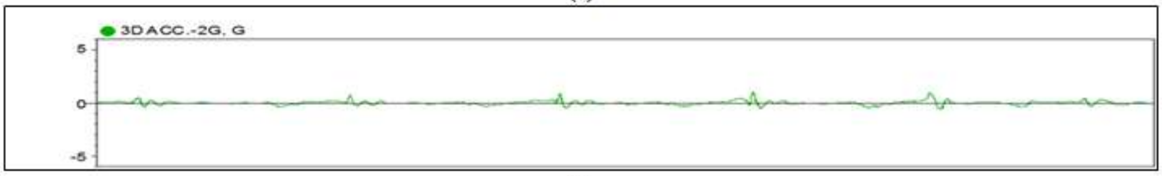
Figure (3): the time – acceleration curves in x-y-z direction for foot: (a) without damping, (b) athletic shoes + ground air, (c) athletic shoes + ground air + silicon damping .





Z

(a)



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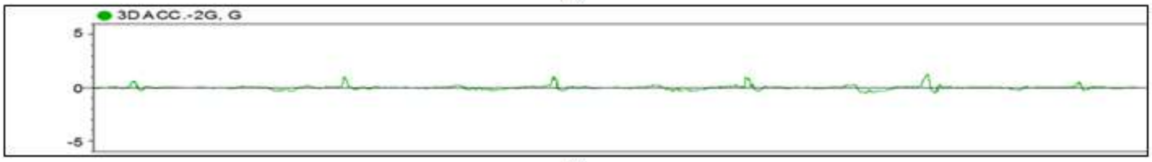

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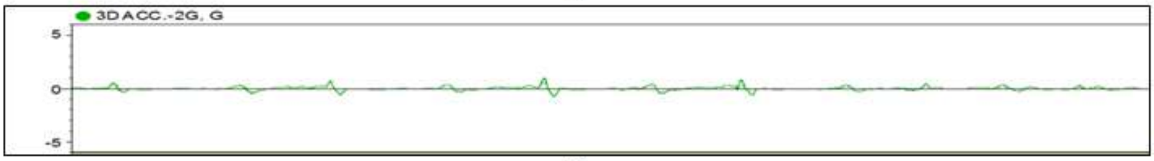

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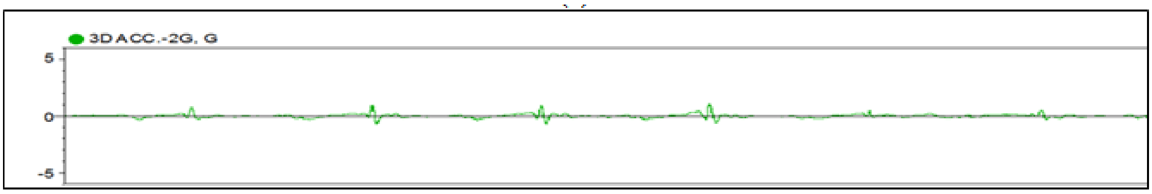
(b)



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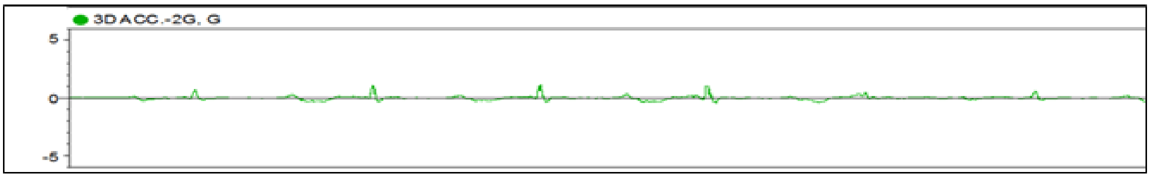

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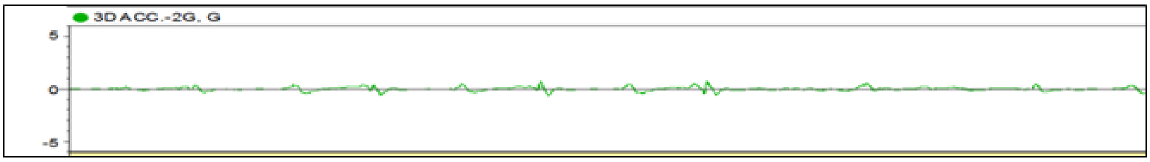


Z

(c)

Figure (4): the time – acceleration curves in x-y-z direction for knee: (a) without damping (b) athletic shoes + ground air, (c) athletic shoes + ground air + silicon damping .

Table (1) the acceleration values of the patient.

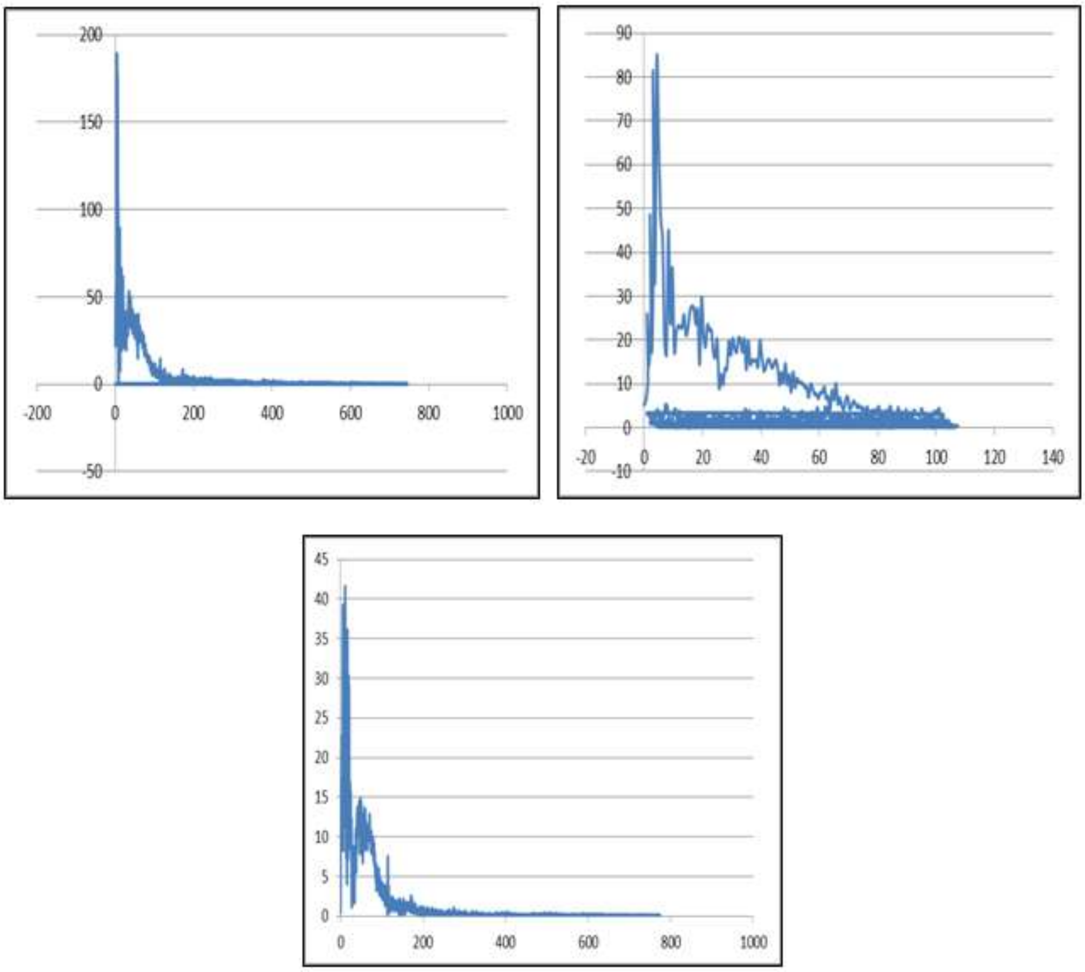
Type of damping	Foot acceleration(N\m2)			Knee acceleration(N\m2)		
	X	Y	Z	X	Y	Z
Without damping (bare foot)	0.41	0.49	0.3	0.31	0.19	0.17
Athletic shoes + ground air	0.25	0.13	0.14	0.32	0.19	0.17

Athletic shoes +ground air + silicon damping	0.38	0.58	0.14	0.28	0.16	0.17

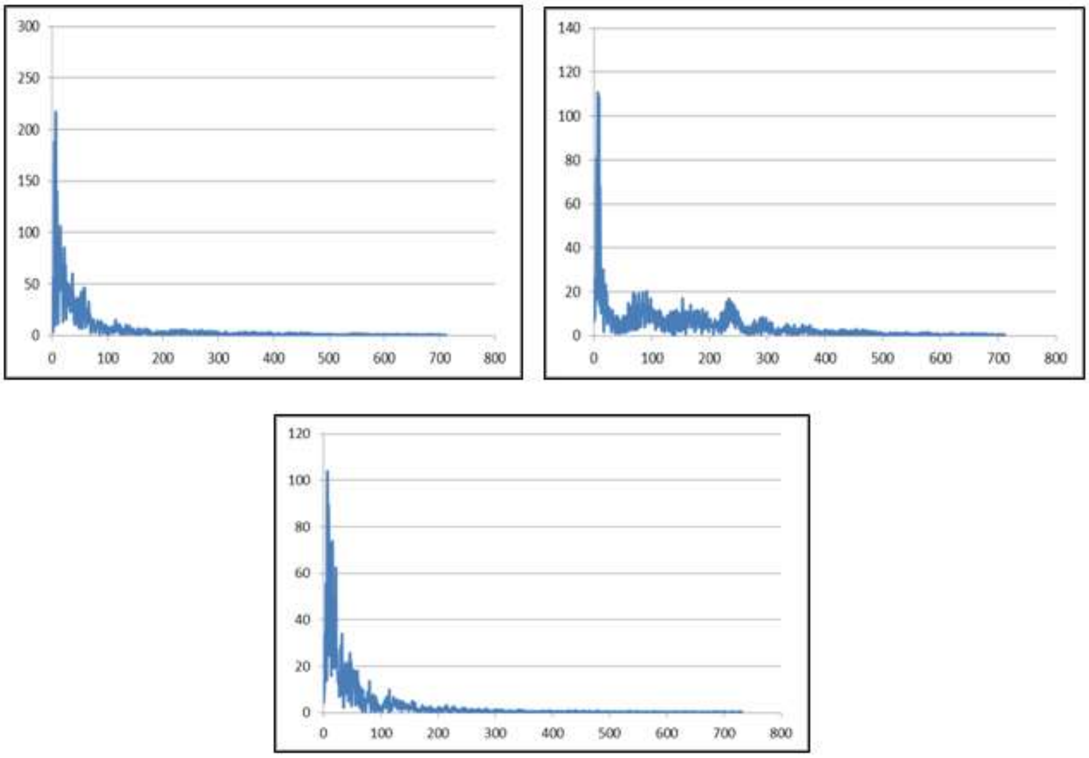
Table (2) Reduction percentage acceleration compared with without damping case

Type of damping	Foot acceleration %			Knee acceleration %			ODSCRA %
	X	Y	Z	X	Y	Z	
Without damping (bare foot)	0	0	0	0	0	0	0
Athletic shoes + ground air	39	73.4	53.3	-3.2	0	0	54.11
Athletic shoes +ground air + silicon damping	7.3	-18.3	53.3	9.67	15.78	0	22.57

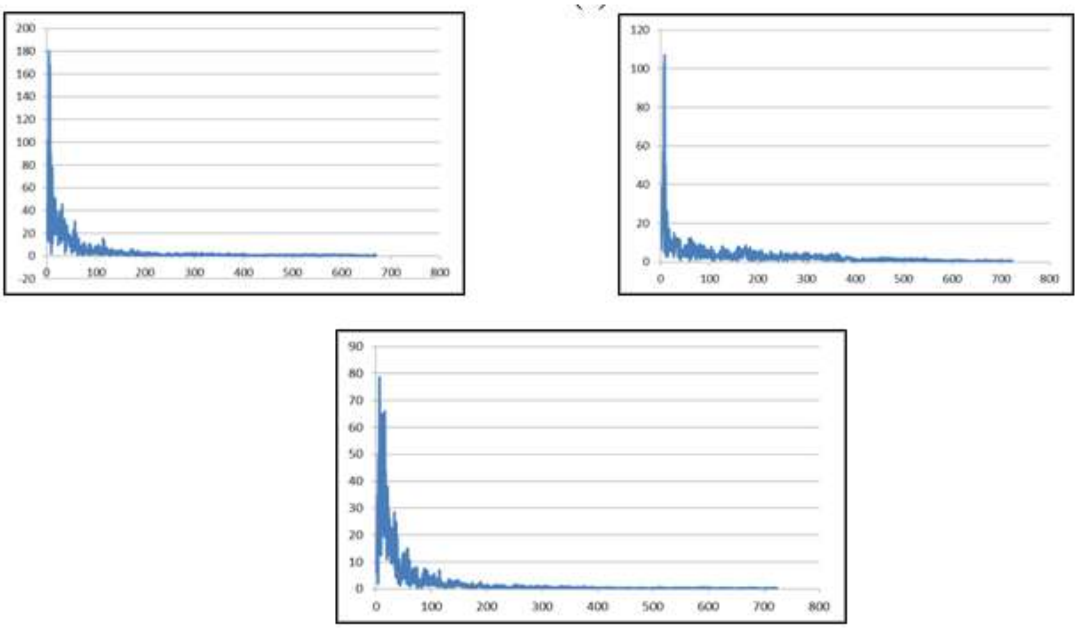
Figure (3),,figure (4), shows the frequency data for foot and knee joints respectively when using different type of damping foot. These results are rearranging in table (3)and table(4) which shows that the level of frequency at knee joint is higher than foot .Results shows that the maximum reduction in frequency is recorded when using Athletic shoes +ground air + silicon damping with percent of 40.3% .



(a)



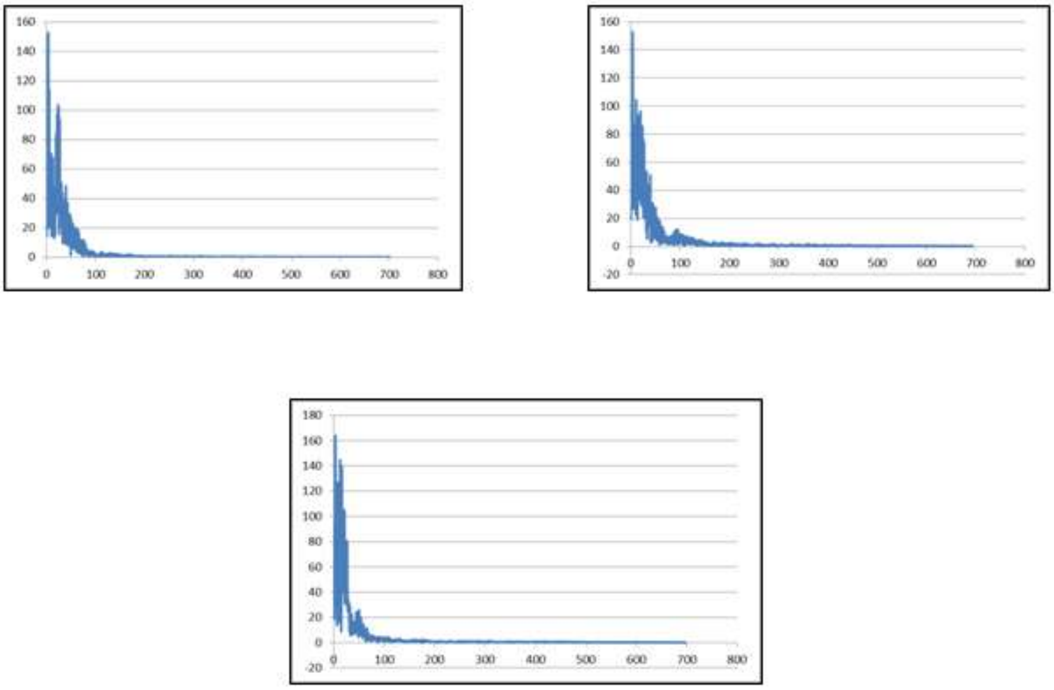
(b)



(c)

Figure (5): the time – frequency curves in x-y-z direction for foot: (a) without damping, (b) athletic shoes + ground air , (c) athletic shoes + ground air + silicon damping .

(a)


160
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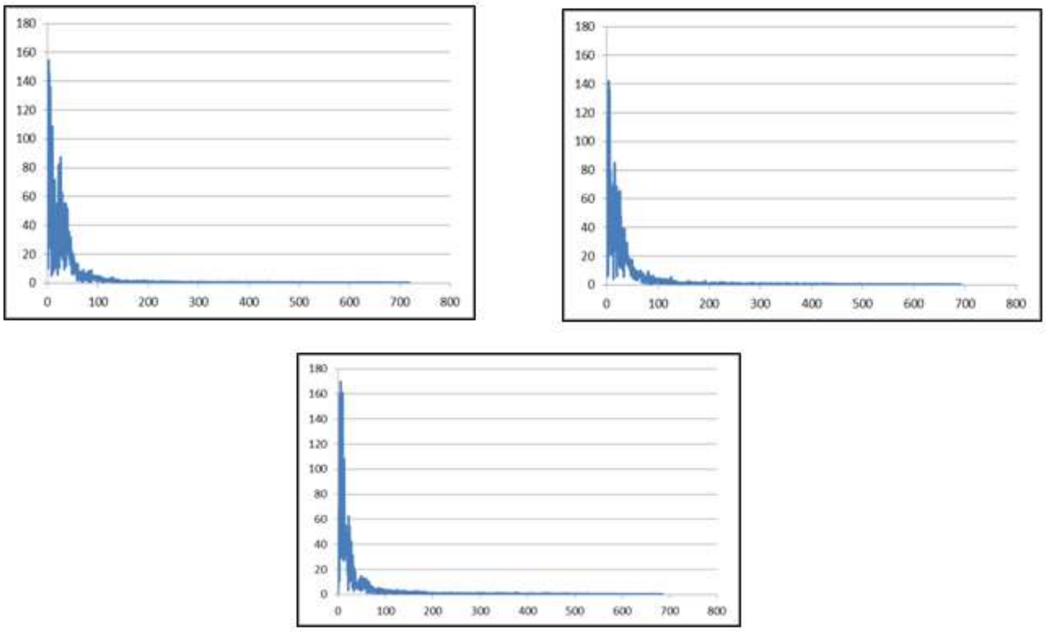
800
180

(b)



(c)

Figure (6): the time – frequency curves in x-y-z direction for knee: (a) without damping, (b) athletic shoes, (c) athletic shoes with silicon damping, (d) athletic shoes + ground air, (e) athletic shoes + ground air + silicon damping.

Table (3) The frequency values of patient (HZ*10^{-3})

Type of damping	Foot frequency (HZ)*10^{-3}			Knee frequency (HZ)*10^{-3}		
	x	y	z	x	y	z
Without damping (bare foot)	0.06	0.06	0.02	0.4	0.8	0.8
Athletic shoes + ground air	0.02	0.05	0.04	0.8	0.8	0.8
Athletic shoes +ground air + silicon damping	0.05	0.03	0.01	0.4	0.8	0.8

Table (4) Percentage of reduction in joints frequency compared with without case.

Type of damping	Foot frequency %			Knee frequency %			ODSCRF %
	x	y	z	x	y	Z	
Without damping (bare foot)	0	0	0	0	0	0	0
Athletic shoes + ground air	66.6	16.6	-100	-100	0	4.7	-37.3
Athletic shoes +ground air + silicon damping	16.6	50	50	0	0	4.7	40.3

III CONCLUSION

1- The maximum reduction in acceleration is recorded when using Athletic shoes + ground air as a damping shoe with percent of 54%.

2- The maximum reduction in frequency is recorded when using Athletic shoes +ground air + silicon as a damping shoe with percent of 40.3%.

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