(الملخص باللغة العربية)

دراسه منحني الطاقه في الذراع
و الرمح القديم خلال مرحله الرمي

علي الرغم من تعدد الدراسات التي تناولت مرحله الرمي الا انها كانت مقصوره علي التحليل السنمائي في محورين ، وان الدراسات التي تتعلق بالرمي كانت قليله ومحدوده .

يهدف هذا البحث الي طرح نموذج رياضي لحساب كميه الطاقه في اجزاء جسم الرامي والرمح القديم .

وقد تم حساب الاحداثيات الثلاثه للمفاصل الزراع واطراف الرمح باستخدام ثلاثه كاميرات ذات سرعه عاليه واجهزه رقمية والحاسب الاليكتروني .

ولقد تم دراسه ومقارنه منحنيات الطاقه في كل من الساعد والعضد والرمح وتبين من هذه الدراسه ان اطول الرميات هي تلك الرميه التي تم تحويل من خلالها اكبر كميه من الطاقه الانتقاليه الحركيه الي الرمح وان منحني الطاقه في الاجزاء التي تم دراستها لم يفسر ان هناك توافق بين النظريات الميكانيكيه والتطبيق الميداني .

وتضمن البحث ايضا النتائج والتوسياط التي يمكن الاستفاده منها في تطوير وتنميه الاداء الفني .

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ENERGY PATTERNS OF THE ARM SEGMENTS AND OF THE OLD JAVELIN DURING THRE THROWING STAGE

ABSTRACT

Although many studies have been carried out on javelin throwing analysis has been confined to two deminsions . A review of the letrature shows investigation attempting to examin the biomechanics of the thrower to be few in number and limeted in scope .

The paper presents a mathimatical model of the energy of a segmar and its application to the energy of the upper and lower arm and to the pre-1986 specification javelin . The model involves the use of three - dimensional coordinatef of the two end points of the segment considered , the data being obtained by the simultaneous use of three cine cameras . In adition , a comparison is made between the energy patterns of the segments considered for a number of differnt throwers . Conclusion are drawn and recommendations made for further study .

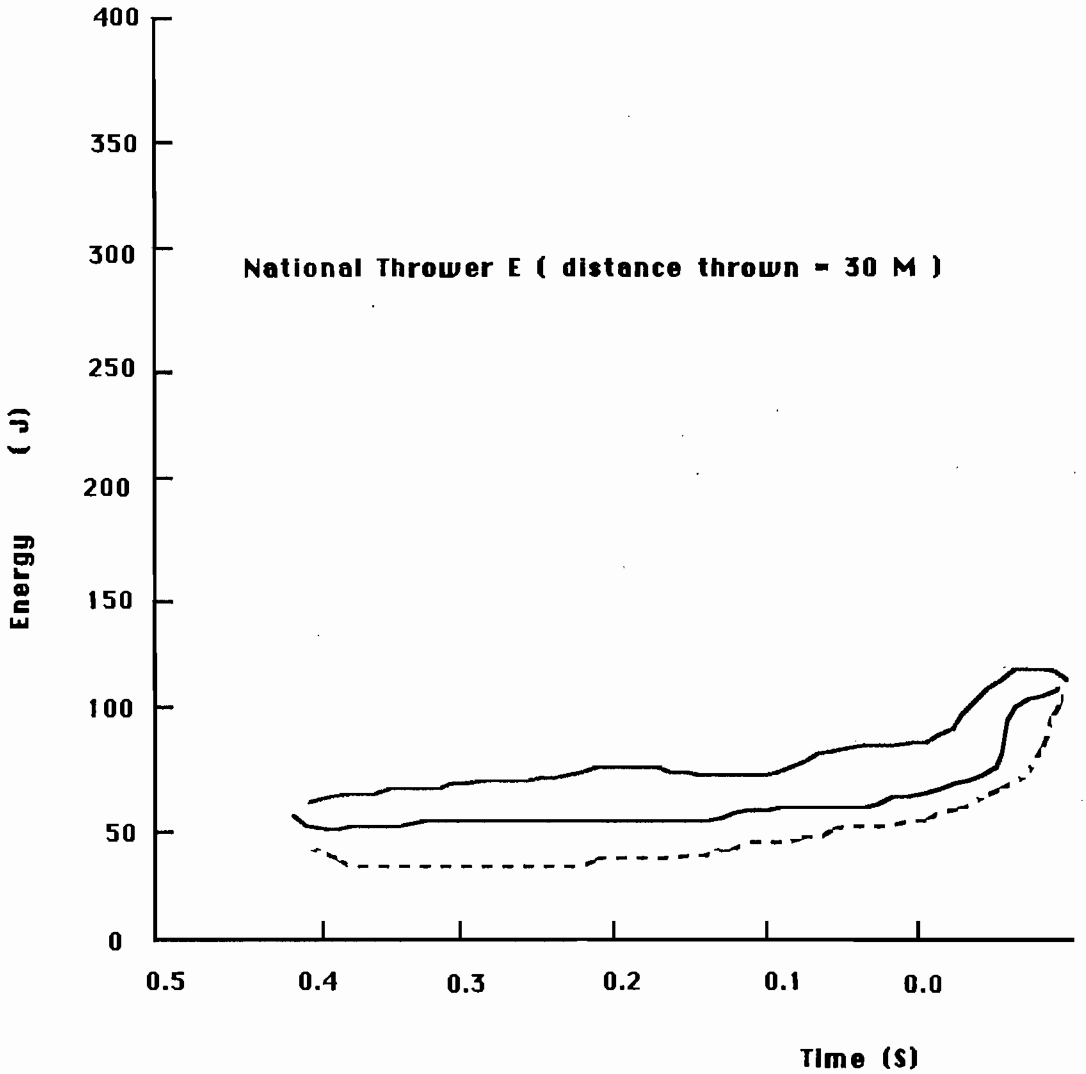
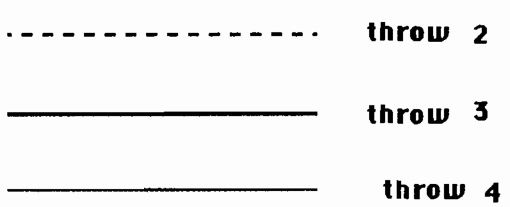


Fig. (10)

Energy pattern of the three segments



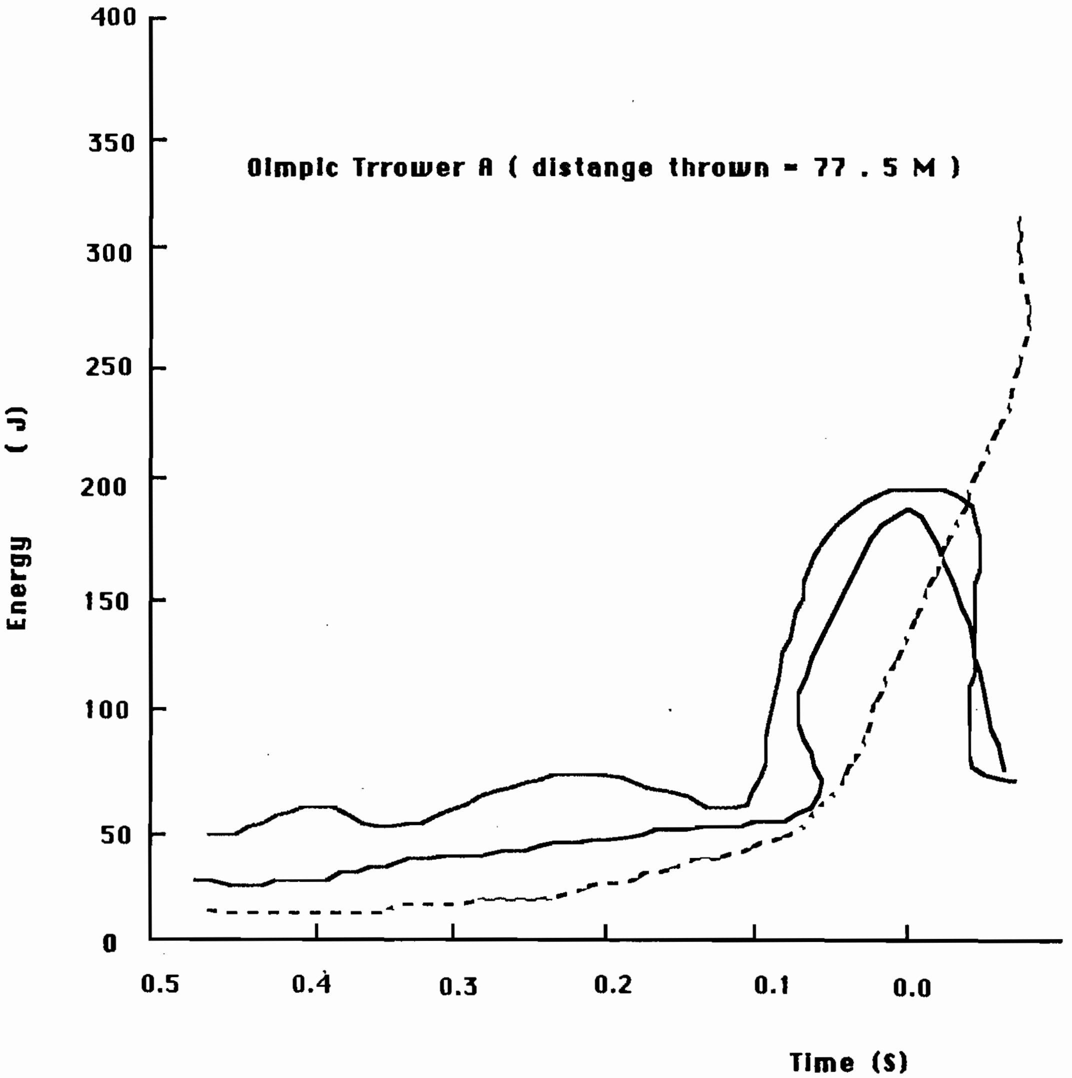
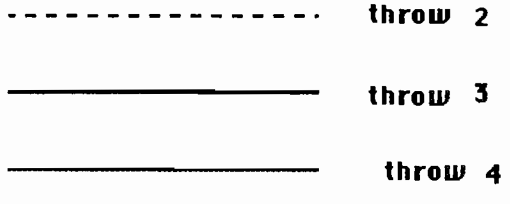


Fig. (9)

Energy pattern of the three segments



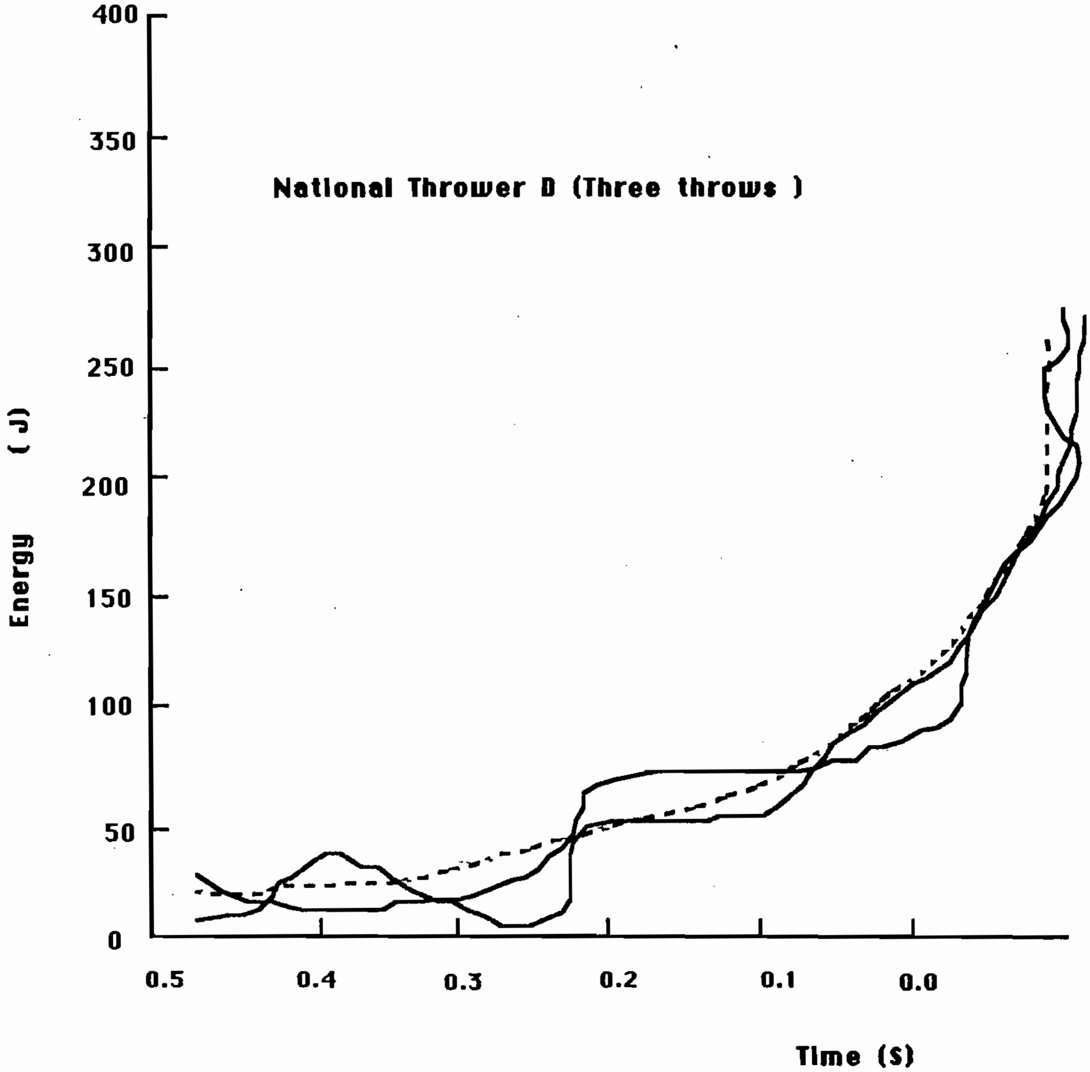
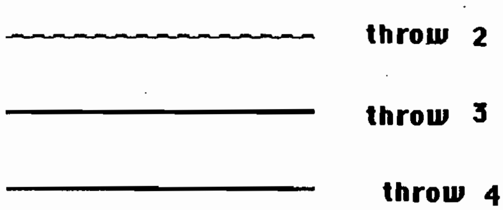


Fig. (8)

Energy pattern of the lower arm



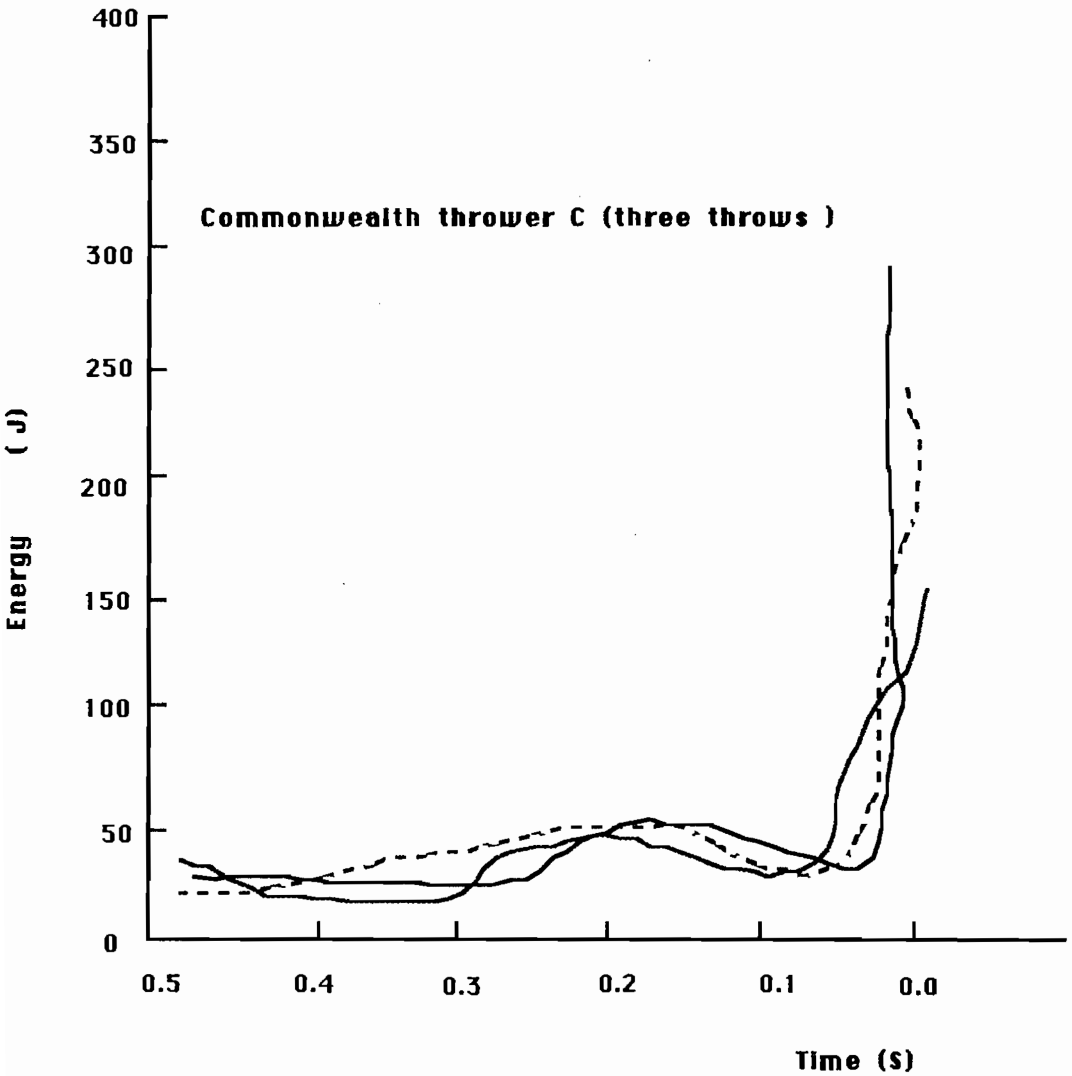
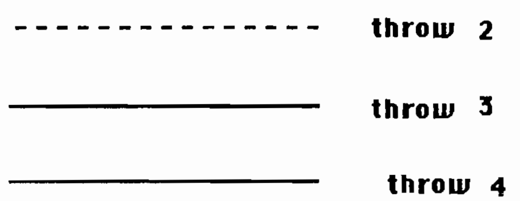


Fig. (7)

Energy pattern of the Upper arm



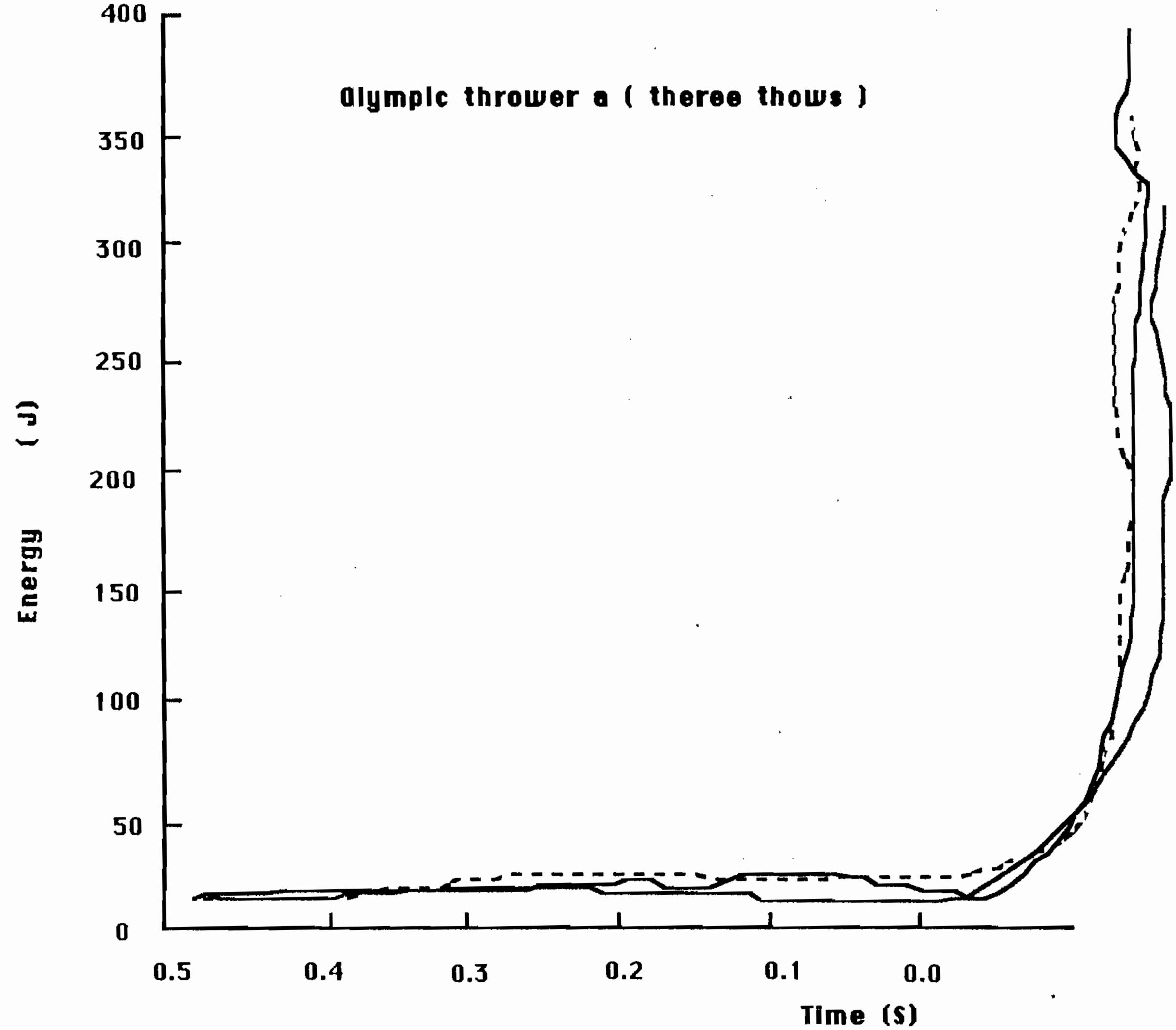


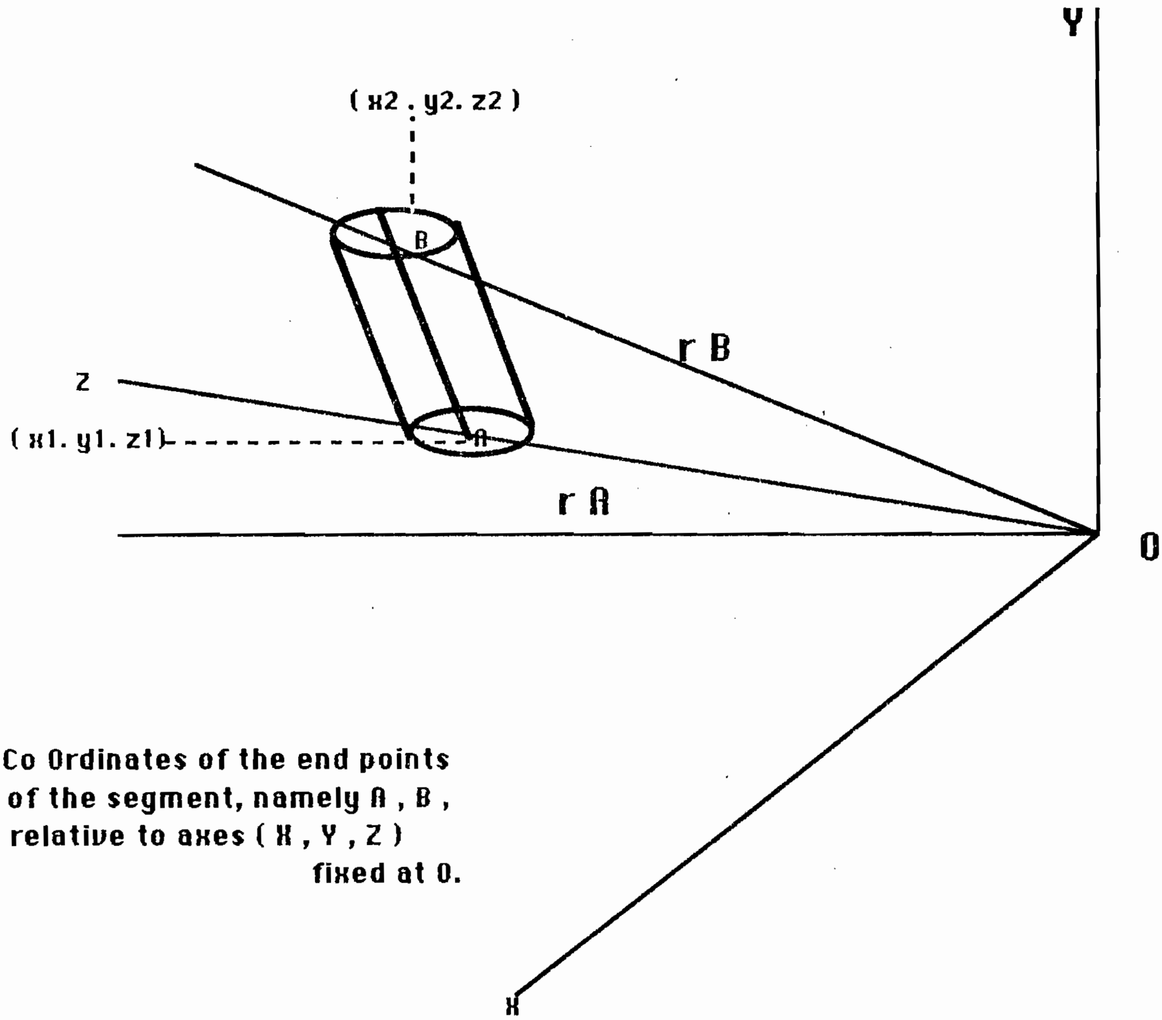
Fig. (6)

Energy pattern of the Javelin

- - - - - - - - - throw 2

———— throw 3

———— throw 4



Co Ordinates of the end points of the segment, namely A , B , relative to axes (X , Y , Z) fixed at O.

Figure (5)

vector representation of the to ends of

the segment

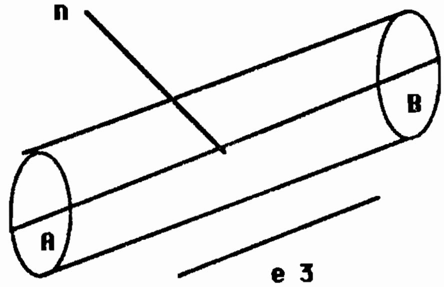


Fig 4

a Unit vactors veprresention along and perpendleular to the Segment A. B

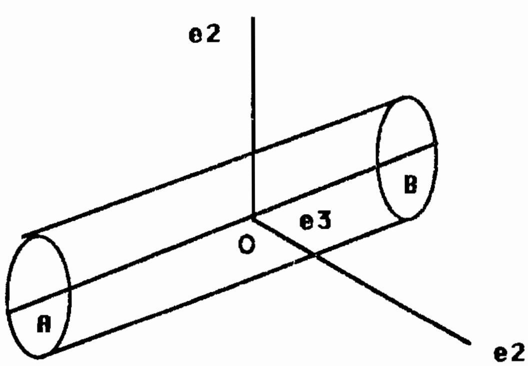


Fig 4

b principal axes fixed in the segment

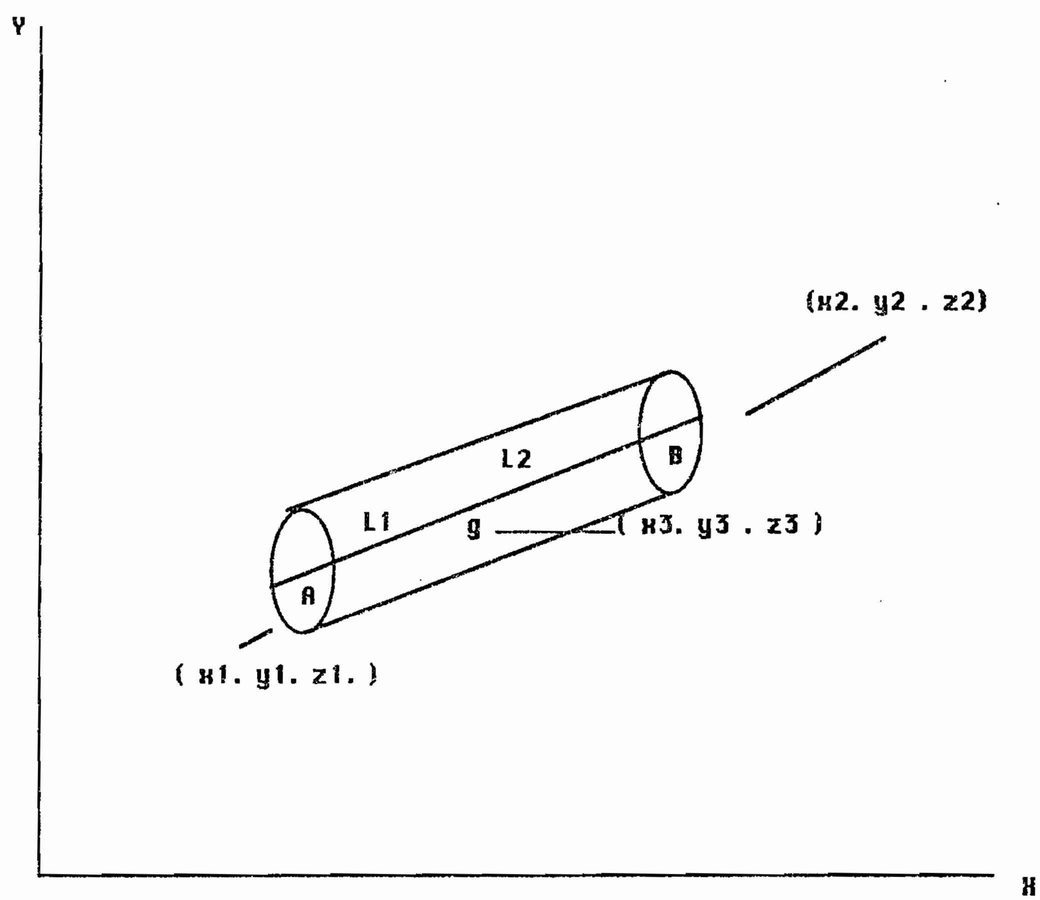


Fig 3
the Co. ordinates of a Segment

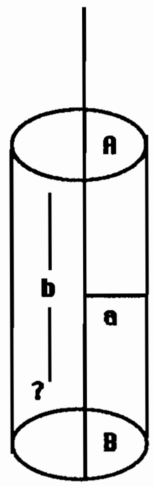


Fig 1

Length Scale of the segment

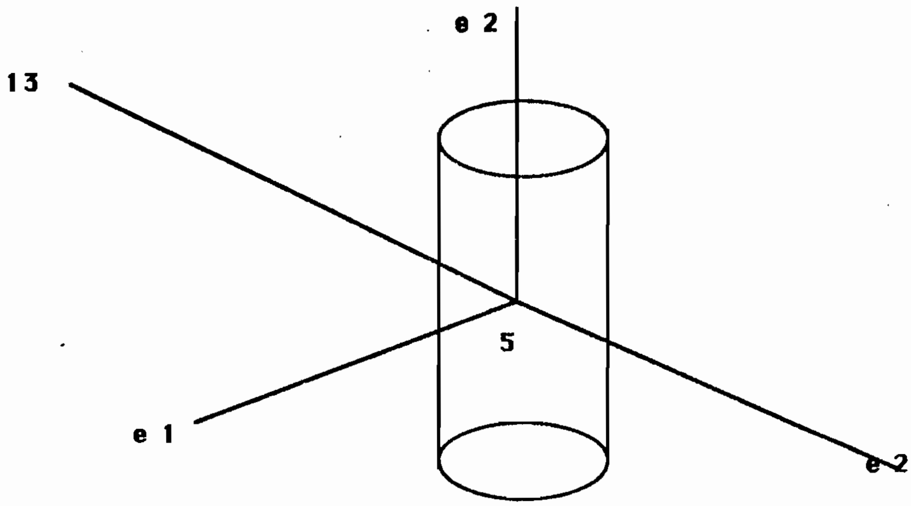


Fig 2

Bady Segment axes

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Recommendations for futher work

It is recommended that further investigation be undertaken on the event to :

1 0 Examine , for purposes of comparison , the the energy patterns of the arm segments with the new javelin .

2 . Examine the contribution of the other body segments to the throw .

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release . Thrower E appeared not to have produced any significant surge of energy in the javelin , a higher level being observed in the lower arm .

Given the variations in energy pattern produced in the 21 throws analysed , it is difficult to draw firm conclusions , particulary in the absence of data from other researchers . It is perhaps significant that the longest throw was not achieved by the thrower who attained the highest energy levels in the three segments considered and further , when the pattern observed showed a decrease in the lower arm energy and finally by a surge of energy in the javelin . This appears to coincide with the basic machanical principle that transfer of energy occurs when a larger body segment decelerates suddenly to allow the energy to pass to another smaller segment .

Conclusions

The following conclusing may be drawn from the energy analysis :

1 . The longest throws were not those in which the maximum kinetic energy was achieved at the beginning of the throwing stage ;

2 . A higher percentage of kinetic energy appeared to be transferred from the body to the javelin by the experienced Throwers A , B and C .

3 . Although mechanical principle indicates the importance of a smooth energy transfer from the arm segments to the javelin , it appeas , it appears from this study that this is difficult to achieve in practice only Olymbic Thrower A in one throw (4) appeared to effect such a smooth energy transfer .

The increase in the levels of energy of the lower arm for both throwers A and B appears to have begun before the left foot hit the ground , between 0.16 s before the release . However , the increase in the levels observed for Throwers D and E were less consistent . In the case of Thrower D , the level appeared to increase before the left foot hit the ground in two throws (0.16 and 0.18 s before the release) but in the other it was difficult to identify the point at whith the increase . In contrast , Thrower E showed increased levels of energy in the lower arm after the left foot hit the ground in two throws (0.11 s and 0.09 s before the release) but before the left foot landed in the third .

4 . Energy transfer

The energy transfer patterns of the javelin and of the upper and lower arm were described in the preceding sections and were seen to vary considerably . A systematic comparison of the energy patterns identified was difficult because of the degree of inconsistency observed . Therfore , the longest and shortest throws of the 21 analysed were compared , namely throw 4 of Thrower A and throw 3 Thrower E .

Figure 9 shows the energy of the three segments , the upper arm , lower arm and javelin , plotted against time . The energy of the upper arm appears to achieve its maximum value at 0.08 s before release and then to decline significantly .

Similary , the energy of the lower appears to peak at 0.07 s before release falling sharply . These drops in the energy levels of the arm segments appear to be followed by surge of energy in the javelin .

In contrest Figure 10 indicates that the energy level in the upper arm of Thrower E did not decrease until 0.5 s before the release and that the highest level in the lower arm was achieved at the point of throwers but also between indindual throws of the same athlete was also apparent . A similar variation in the time at which the energy levels started to increase significantly was also indicated . Finally the maximum energy was reached in each throw at different times in relation to the release . Table 5 showes the time at which maximum energy was achieved for each athlete's longest throw .

TABLE 5

MAXIMUM ENERGY BEFORE RELEASE

Thrower	Time before release (s)
A	0.08
B	0.00
C	0.00
D	O.O4
E	O.OO

3. The lower arm

The instantaneous energy of the lower arm was calculated and the energy pattern examined for each throwing during the throwing stage . Figure 8 shows different energy patterns of the upper arm produced in three throwen by the National thrower D . An examination of the patterns indicates that maximum energy of the lower arm occurred at the release in all except three cases , the most notable exption throw 4 of Thrower A , his longest , in which the maximum energy occurred 0,07 s before the release .

Fgure 6 shows the energy pattern of the javelin produced for three throws by the Olympic athlete A . All five throwers produced comparable patterns overall although the Olympic athletes A and B showed the greatest degree of consistency in the patterns produced .

The transfer of energy in the case of Thrower A commenced 0.12 s, 0.14 s and 0.16 s in throws 2, 3 and 4 respectively , before the point of release , although in each case , this coincided with the landing of the left foot . Thrower B , however , begin to transfer energy to the javelin approximately 0.1 s before the point of release but in this case between 0.04 and s after the left foot hit the ground .

Thrower C transferred energy to the javelin at different time in relation to the point of release (from 0,13 s to 0.16 s) ; in two cases (throws 1 and 2) this occurred immediately and in one case , before the left foot hit the ground .

Thrower D appears to transferred energy to javelin 0.04 - 0.08 s after the left foot hit the ground in each case ; the time between the transfer of energy and the point of release varied from 0.14 s (throw 1) to 0.12 s (throws 3 and 5) . Thrower E also appears to have transferred energy to the javelin after the left foot hit the ground but the transfer occurred only 0.09 s from the point of release . The interval between the transfer of energy and the landing of the left foot varied from 0,06 s to as much as 0.09 s .

2. The upper arm

The instantaneous energy of the upper arm calculated and the energy pattern examined for each throwwer durhng the throwing stage . Figure 7 shoes the different energy patterns of the upper arm produced in three throwers by the Commonwealth athlete C. A large variation in the magnitude of the instantaneous energy not only between the

TABLE 4

THE KINETIC ENERGY AT THE BEGGINNING OF THE THROWING STAGE AND ATTHE RELEASE

Thrower	Throw number	Kietic energy at beginning of throw (J)	Kinetic energy at release (J)	Percentage transferred (%)	Weight of thrower (kg)	Distance thrown (m)
A	1	1062.5	264	24.8	85	72.0
	2	800.5	310	38.8	,,	75.0
	3	934.8	281	30.1	,,	74.0
	4	895.4	359	40.1	,,	77.5
B	1	879.0	182	20.7	65	65.0
	2	940.7	161	17.1	,,	60.0
	3	878.8	196	22.4	,,	67.0
C	1	1140.4	254	22.3	85	65.0
	2	1144.8	250	21.8	,,	65.0
	3	Standing throw	204	-	,,	50.0
	4	922.9	270	92.3	,,	71.0
D	1	874.7	155	17.7	55	53.0
	2	853.2	164	19.2	,,	55.0
	3	790.1	165	20.9	,,	57.0
	4	715.0	165	21.6	,,	57.0
	5	795.9	156	19.6	,,	57.0
E	1	878.8	90	13.9	55	40.0
	2	527.8	89	16.9	,,	40.0
	3	770.8	80.9	10.9	,,	30.0
	4	681.7	72.4	10.5	,,	35.0
	5	573.0	85.5	14.9	,,	35.0

TABLE 3

DESCRIPTION OF SUBJECTS

Thrower	Age (years)	Experience (years)	Competitive standard	Best throw (m)
A (male)	29	13	Olympic	77.5
B (female)	28	12	Olympic	67.0
C (male)	21	7	Commonwealth	71.0
D (male)	15	5	National (junior)	57.0
E (female)	23	5	National (senior)	40.0

It can be seen clearly from Table 4 that , with the exception of Thrower E's first throw , the longest throws were not those in which the maximum kinetic energy at the beginning of the throwing stage was achieved . It also indicates that in each case the longest throw was achieved when the ath' ete transferred the highest percentage of the energy to the javelin at release . This result suggests that the efficiency of the linetic energy to the javelin is more important than the amount of energy generater during the run-up (Table 4) .

RESULTS

This study is understood to be the first attempt to quantify the energy transfer from thrower to javelin . Five throwers of different age , ability and experience , three male and two female , agreed to take part in this study ; they are described in Table 3 . The study considers three segments , the javelin , upper arm and lower arm ; each is considered separately . For the purposes of comparison , the point of release taken to be the point of reference .

1 . The Javelin

The kinetic energy at the beginning of the throwing stage for each thrower was calculated and compararerd with the linetic energy of the javelin at the release (Table 4) . The percentage of kinetic energy transferred from the thrower to the javelin was calculated ; this is also shown in Table 4 . The correlation coefficient of the percentage of energy transferred to the javelin versus the distance travelled by the javelin was then calculated for all throws using the least square method and found to be 0.86 . Finally , the instantaneous energy of the javelin was calculated and the energy pattern of the javelin examined for each thrower during the throwing stage .

In order to relate the data from the three cameras , given the problem of ptecise synchonization , digitizing began 5 frames before that in which the right foot hit the ground and was continued every second frame , until the point of release . The accuracy of digitizing for those points which were clearly visible was +/- 10 mm , compared with +/- 20 mm for the points which were blurred . The accuracy of digitizing was estimated by taking one clear and one blurred point , digitizing each six times and averaging the results . Measurements were recorded to the nearest 0.1 mm .

The equations used to obtain the three dimensional co-ordinates were developed by Lindsay (1983) based on the work by Martin and Pongratz (1974) . The cameras were positioned 10 deg away from the global cartesian axes (origin) . Therefore , a Fortran program was written to rotate the X and Z co-ordinate data through 10 deg about the y axis .

The 3-D co-ordinates are subject to experimental error due to digitizing and imprecise site measurements in setting up the square and the cameras . In order to reduce the effect of these errors , a number of numerical methods of smoothing the data have been used in sports biomechanics , but it is widely accepted that the cubic spline function is the most appropriate (Rice , 1969 , Greville , 1970) Robert et al. , 1974 Zernick et al. , 1976 , McLaughlin et al . . 1977 Wood , 1982) ordinates of the reference frame fixed in the centre of the runway near the foul line . Four markers were then placed on the ground to form a square (4 m by 4 m) with the origin at the centre . The markers and cameras were aligned with the using a theodolice Identification plates were included in the background of each camera to identify the trail number during the digitizing .

Camera 2 was positional at 10 deg anti-clockwise from the horizontal (x) axis behind the thrower 20 m from the origin to ensure that it did not interfere with the thrower's run-up . Cameras 1 and 3 were positional 23m and 25 m respectively from origin 90 deg from a line between camera 2 and the origin . The accuracy of setting up the square was +/- 3 mm and the camera heigh and distance accurate to within +/- 1 mm and 20 mm respectively .

Fluorescent yellow sticky labels were used to mark the athletes' joints and fluorescent yellow insulating tape to mark the javelin at fixed distances from the tip and the tail . These types of markers had been used successfully (Al-Kurdi , 1987) .

The camera speed was set at 200 f.p.s and the cameras switched on by separate operators as the thrower passed a special marker on the runway . The distance travelled by the javelin was estimated on the basis of markers plced in the throwing sector at 5 m intervals to within approximately 0.25 m

A Ferranti Freescan digitizing table (1.524 m x 1.67 m) was used . The manufacturer claims it is able to locate co-ordinates to an accuracy of +/- 0.25 mm with a reliability of +/- 0.125 mm . The processed films were projected on to the digitizer table from the room above via a 45 deg. mirror through a hole in the celling . The projected image of the thrower was approximately one-third life size and every second frame was digitized .

$$W.e3 = W.(rB - ra) \qquad (11)$$
$$= W x (X2 - X1) + (Y2 - Y1) + Wz (Z2 - Z1)$$
$$= O$$

Using the Gaussian elimination method , the first two equations in (10) togather with that from (11) may be solved to produce :

$$Wz = \frac{(X2 - X1) (V2 - V1) - (Y2 - Y1) (U2 - U1)}{rB - rA2}$$

$$Wy = \frac{(U2 - V1) + (Y2 + Y1) Wz}{Z2 - z1}$$

$$Wx = \frac{(V2 - V1) + (X2 - X1) W z}{Z2 - Z1}$$

If the segment happens to lie entirely within X - y plane , then it is necessary to rain the final equation in (10) whilst discarding of the former two . Exactly which is retained is immaterial unless the segment should also happen to lie along a line parallel to the X or Y axes . Having obtained the necessary information about h, v, and w the energy model for a segment can be applied .

Experimental Procedure for Obtaining the three - Dimensional Co-ordinates

The experimental technique used was that described in greater detail in Al-Kurdi , 1987 . Three 16 mm high - speed pin - registered Locam cine camiras mounted on tripod with 25 mm lenses and power from rechargeable battery packs were used . The origin of the co-

May be imposed , where W. e3 = 0 represents the scalar product . This enables the angular velocity to be determind uniquely from the coordinates and velocities of the end point A an B of the segment . Without the above restriction , uniqueness would be impossible since the points A and B could retain their former position and velocities whilst arbitary additional rotations about the line AB were imposed .

The method used to obtain W was as follows . With the axes (X , Y , Z) fixed in space at O , the end points of the segments namely , A and B are denoted by the vectors rA and rB respectively (Figure 5) . The position vector of B relative to A is :

$$rB - rA = (X2 - X1 , Y2 - Y1 , Z2 - Z1) \quad (7)$$

And velocity of B relative to A is

$$vB - vA = (U2 - U1 , V2 - V1 , W2 - W1) \quad (8)$$

Where (U1 , V1 , W1) and (U2 , V2 , W3) are the velocities components of the end points A and B respectively .

This relative velocity may be expressed via instantaneous angular velocity , resulting in $VB - VA = W \times (rB - rA)$ (9)

where , X represents the vector product .
The resulting equations in component from area :

$$U2 - U1 = Wy (Z2 - Z1) - Wz (Y2 - Y1) \quad (10)$$
$$V2 - V1 = Wz (X2 - X1) - Wx (Z2 - Z1)$$
$$W2 - W1 = Wx (Y2 - Y1) - Wy (X2 - X1)$$

As the above equations are singular , no unique solution is available , but this problem can be surmounted by imposing the condition imposed earlier that is ;

3. The rotation kinetic energy of the segment

The instantaneous angular velocity W is expressible in the form :

W = Wn n + W3 e3 (4)

Where e3 and n are unit vectors along and perpendicular to AB respectively (Figure 4a) . If one considers axes through the centre of mass , along and perpendicular to AB , then owing to the symmetrical nature of the segment , all products of inertia with respect to those axes can be considered small . These are appropriate principal axis , fixed at the centre of mass of the segment , may be chosen as showen in Figure 4b , with el and e2 any two orthogonal vectors in plane perpendicular to e3 . The moments of inertia about axes el and e2 are nearly identical owing to the segments symmetrical properties . This , togather with e1 bein taken in the n direction , allows the rotational kinetic energy to be expressed as

1/2 (NWn2 + (CW3 2) (5) .

Where N and C are the moment of inertia about the e1 and e3 axes respectively . Further , since the length scale of the segments in the e3 direction greatly exceeds that in its perpendicular direction (Figure 4a) , c/N may be considered small , allowing the rotational kinetic energy to be approximated by :

1/2 NW n 2

4. The angular velocity of the segment

As the rotational kinetic energy only requires the component of the angular velocity in the n direction the constraint

W.e3 + 0 (6)

TABLE 2

Moment of inertia of body segments about transvers axis through their centre of gravity (Whitsett 1963)

Segment	Moment of Inertia
Head	0.0183
Trunk	0.9300
Upper arm	0.0157
Lower arm	0.0056
Hand	0.0004
Upper leg	0,0372
Lower leg	0.0372
Foot	0.0028

2. The liner velocity (U3 , V3 , W3) of the centre of gravity of the segment

The velocity is readily obtainable from graphs based on the experimental data of the X3 , Y3 and Z3 co-ordinates plotted againist time . The gradients of these three graphs produce the components of the velocity of centre of mass ; namely , U3 , V3 and W3 .

To the transvers axis through the centre of gravity of a segment whitsett (1963) computed the moment of inertia relative to the principal axis of a segment . Therefore , his data was selected as being appropriate for use in the energy model (Table 2) . The value taken for the moment of inertia of the javelin was that reported by Terauds (1985) , which is believed to be the only reported value .

The value of h, v and w can be calculated from the cine film data . Since these calculations are to from the major part of this model , each va lable will be discussed in detail .

1. The co-ordinates (X3,Y3, Z3) of the centre of gravity G of the segment

- The co-ordinates of G (X3 , Y3 , Z3) , may be expressed as

$$X3 = x1 + \frac{11}{11 - 12} (x 2 - x1)$$

$$Y3 = Y1 + \frac{11}{11 + 12} (Y 2 - Y1) ,$$

$$Z3 = Z1 + \frac{11}{11 + 12} (Z2 - Z1)$$

Where , A and B are the ends of the segment with the coordinates (X1 , Y1 , Z1) and (X2 , Y2 , Z2) respectively and 11 and 12 are the lengths of AG and GB respectively (Figure 3)

TABLE 1

Weights of body segments relative to total body weight and location of centre of gravity of body segments Claser et al . 1969)

Segment	Relative Weight	Relative location ,centre of gravity from proximal end
Head	0.073	0.460
Trunk	0.507	0.380
Upper arm	0.026	0.513
Lower arm	0.016	0.390
Hand	0.007	0.820
Upper leg	0.103	0.372
Lower leg	0.043	0.371
Foot	0.015	0.449

g is acceleration due to gravity ;

h is the height of the centre of mass above a particular reference level (the origin) ;

I is moment inertia of the segment about its instantaneous axis of rotation through the center of mass ;

v is the velocity of the centre of mass ;

w is the angular velocity of the segment .

Both kinematic and anthropometric information of ce tre of mass and moment of interia of the segment .

Data concerning the mass and location of the centre of each segment in this study were based on measurements reported by Clauser et al . (1969) , (Table 1) .

These measurements were chosen sinco Clauser's studies were carried out using cadavers in which the location of the centre of the segment can be found satisfactorily .

The energy model requires the calculation of the moment of inertia relative only ine the energy transfer within the arm and the old specification javelin during the throwing stage , which starts when the right foot hits the ground at the start of the last stride and ends when the javelin is released . The technique used in this study to calculate the instaneous energy of segments involves the use of the three-dimensional coordinates of the two end points of each segment (Figure 1) , the data being obtained from cine film . The segments considered are the lower arm and the javelin .

Basic assumptions

The energy model is based upon the following assumption :

a) Body segment assumed to be rigid and symmetrical about its axis .

b) A set of axes (e1 , e2 , e3) are fixed at the center of gravity G , (x3 , Y3 , z3) of the segment to coincide with the principal axes which translate and rotate relative to an inertial set of axes .

c) Since b a axes in the perpendicular plane , so that any contribution to the rotational kinetic energy from the component of the angular velocity along AB may be neglected (Figure 1) .

b) The el axis chosen such that the component if the angular velocity in the plane perpendicular to the axis of the segment acts along it (Figure 2) ; in other words w' e1 and e3 are coplanar .

Calculation of Parameters

The instantaeous energy of a segment can be expressed as :

E = Potential energy + translational kinetic energy + rotational kinetic energy

= mgh + 1/2 mv2 + 1/2 1 w2 (1)

where m is the mass of segments ;

" Because of the three -dimension nature of the throwing motion , only limited research - based information is available on body segment contributions to the magnitude and direction of the javelin's velocity at release "

Paish (1972) stated that the speed at which the arm " strikes " the javelin is responsible for a larg proportion of the throw , but provided no quantitative measurement to support his statement . The ab- referred to by Gregor et al . sence of quantitative measurements was (1985) who suggested that an investigation of the mechanical energy transfer was important . In their study of the javelin throw , Ikegami et al . (1979) expressed the view that ,

" The earlier part of the throwing motion can be considered as a process of transformation of kinetic to elastic energy and the kinetic energy of the run-up may be transferred to a part of the kintic energy of the javelin through this process . "

Suggesting areas for future research , Hubbard (1984) stated that ,

" Of course there is a vast difference between knowing the optimal release conditions and knowing the optimum way to throw the javelin . The latter implies a knowledge of the biomechanics of the thrower , an important area of research . "

Thus , a need to examine the cotribution of the body segments to the throw is indicated by the literature .

Javelin coaching literature suggests that the muscles should act in the sequence of legs , trunk and finally the arm , and that the arm makes the most significant contribution (Paish , 1972) . The aim of the present study , therefore , is to develop an energy model to exam-

ENERGY PATTERS OF THE ARM SEGMENTS AND OF THE OLD JAVELIN DURING THE THROWING STAGE .

*ZIAD DARWISH ELL KHORDY .
** ESSMAT DARWISH ELL KHORDY .

Itroduction

Previous studies of javelin throwing have concentrated mainly on two aspects , namely the aerodynamic of the javelin in flight and the quantitative parameters at release . The few scientifically or mathematically - based studies have been carried out on the biomechanics of the thrower using tow - dimensional cinematographic .

Although a number of researchers (Miller and Munro , 1983 , Gregor and Pink , 1985 , Komi and Mero) have referred to the fact that javelin throwing is a three - dimensional event and that a single camera fails to describe the event precisely , no systematic study has been carried out in three-dimensions . Miller and Munro (1983) stated that ,

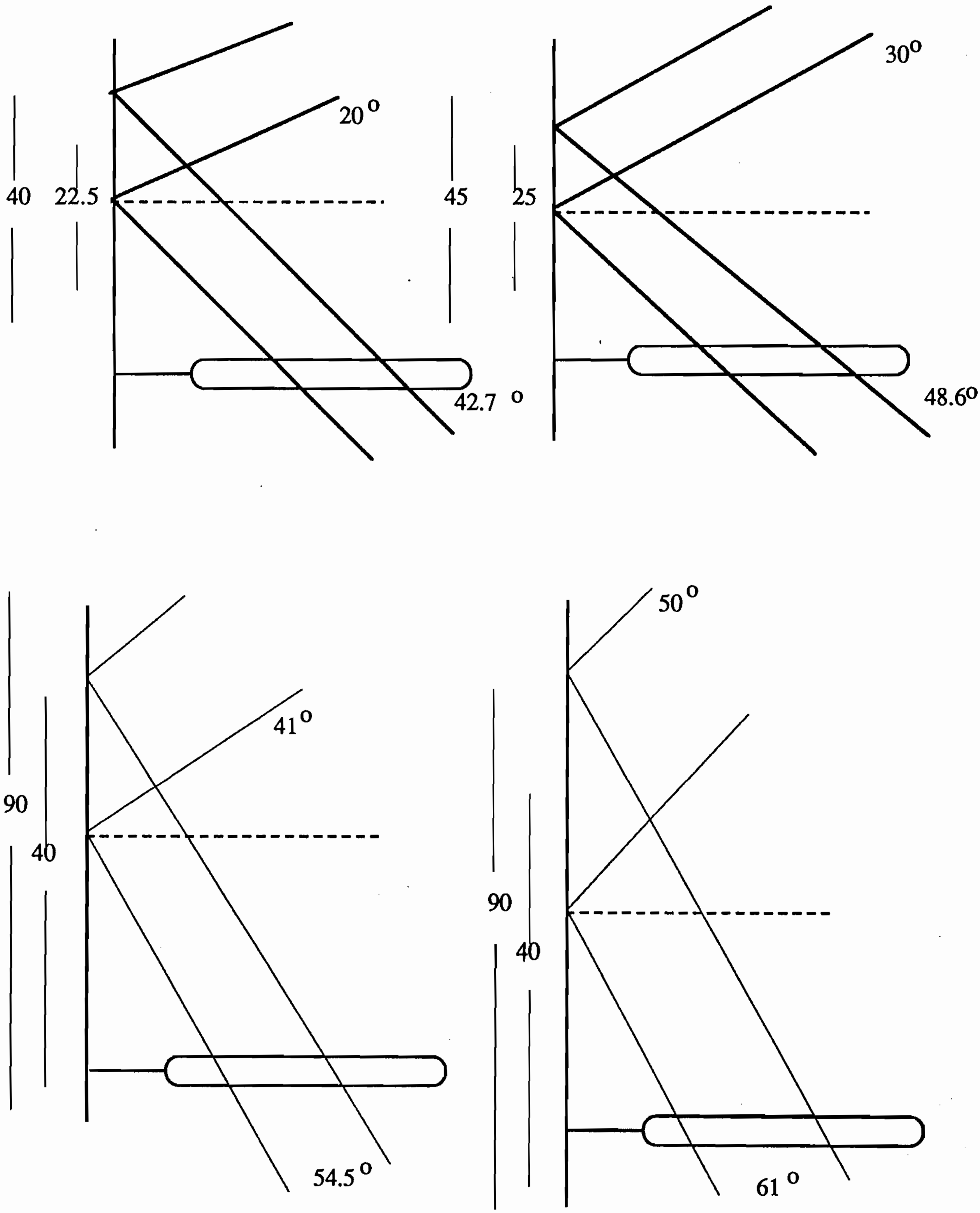

FIG. (3) : Disance form the ring to eash incidence
[20 , 30 , 40 , 50]

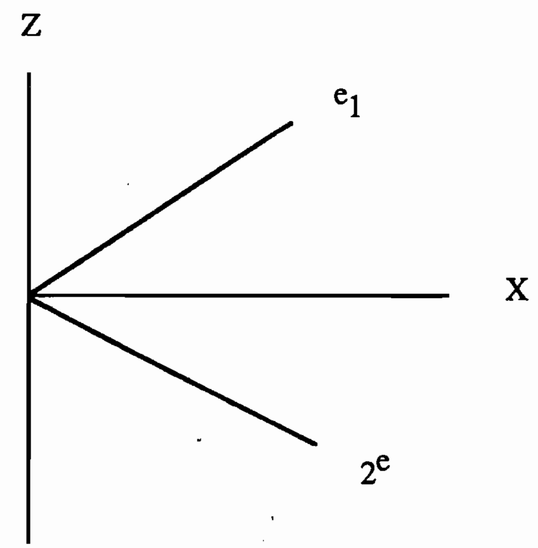

FIG. (1) : Skematic drawing of incidence and reflecation angles .

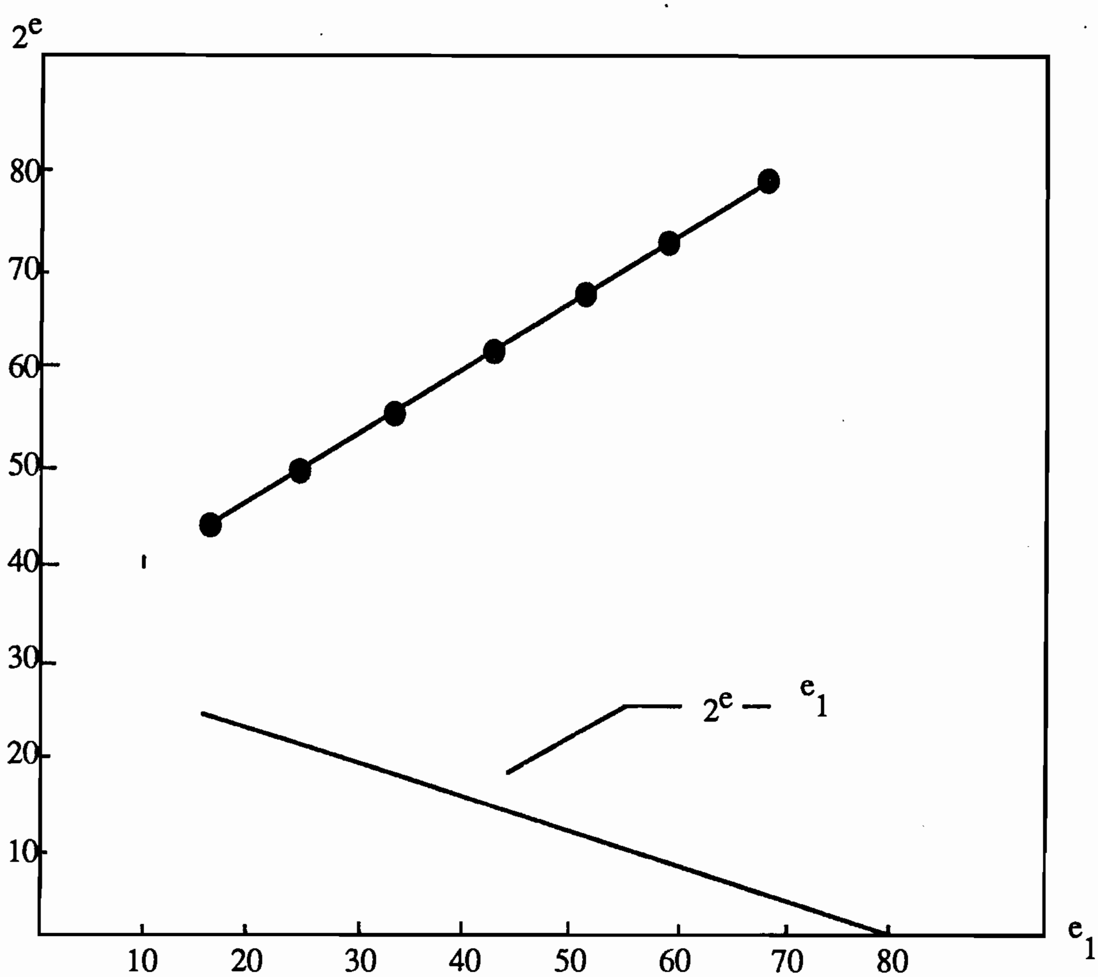

FIG. (2) Relation of reflection angle to each incidence angle and the outcome difference

4 . CONCLUSION

This,all shows that there is some weighting added to the incidence angle with maximum value at 0o incidence angle and decreased with increase with incidence angle increase angle increase until this weighting reaches 0ovalue at 90o incidence angle.

It can be concluded as friction force was the only variable responsible for the change in the reflection angle and because friction does not depend on velocity of spinning (that velocities are low) . It can be concluded the reflection angle does not not depend on the variability in w constrained it exists to cause friction .

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0 in	20	30	40	50	60	70	80
0 Reflceted	42.7	48.6	54.4	60.3	66.4	73.2	80.1
0 Differance	22.7	18.6	14.4	10.3	6.4	3.2	.1
Contact min.pt. max.pt. (cm)	22.5 40	25 45	30 62	40 82.5			

Both of this latter curve and this table indicate that for a ball with incidence angle 20o with a spinning and a contact point between 22.5 and 40 should fall in the ring and further more , for other incidence angles the contact point is illustrated in Fig. 3.

As the rection time is infenitzmal small . The value of this part will tend to zero and can be neglected and then , the govering equation will com to

O2 = Tan-1 (tan O + U)

This equation does show the reflection angle depending on on incidence angle O1 and the coeficient of friction only .

3. RESULTS

This equation is implented in curve shown in fig.2. this curve between angle 01and 02 where their shows that for incidence angle 20o thereflection angle is42.7lo.4 and there is difference of 22.7o . For 40 incidence angle , the reflection angle is 54o and the difference decreased to 14o . For 60o incidence angle,the reflection angle is 60o and the difference decreased to 6o.at 90o.incidence angle the reflection angle is almost 90o and the difference is almost zero . This difference between the incidence angle and its reflection angle indicate that there is some weighting added to incidence angle . This weighting is largest at incidence angle 0o and is smallest at incidence angle 90o . This relation is represented as follows :

O2= tan-1 -1 33 / 75 Oi + 33o

Fig. 2 shows the location of the contact point between the ball and the board under spinning and no spinning conditions as represented in the following table .

Alternative two and three show that the sliding is attained thus u will reach its maximum value . . .

As u = 0.56 for leather on cast iron *2

Here , due to the nature of the game , low velocities are used , as well as , the fact that only limited distance befor reflection is considered . We may assume with confidence that the velocity may not be affected by the spinning , and alternative one is rejected . Then

Tan O = Fz / Fx

= Tan -1 (02 - u - mg / Fx)

0 = Tan -1 (- Tan 01 - u - mg / Fx

This operation shows the interaction between 0 1 , 0 2 , coefficient of friction and the value of the gravity force , and more insight will be forward to these magnitude along

$$\frac{mg}{Fx} = \frac{mg}{m (V1 - O) \sin O / t}$$

$$= \frac{g . t}{m \ V1}$$

Here V is approximately 6 = / sec .

The this value will tend to $\frac{9.8 \ t.}{6}$

In evaluating forces after reflection and considering NEWTON LAWS of DYNAMICS , the component of F in x direction will reflect with equal magnitude and in opposite direction . Also , the component of F the z direction is same in magnitude and direction . Furthermore , a friction force will be contributed in the z direction , thus after reflection .

Fx = F cos O

Fz = F sin O - u Fx - mg .

Where u is coefficient of friction .

Now, if we consider the part with friction , as the ball is approaching the basket ring with angular velocity cu due to spinning in the direction o motion i. e. rotating around its center of mass . It's outer surface will have velocity equal to w. r. where is the radius of the ball .When the ball surface contact the basket board or the ring , this surface velocity may perform one of these alternatives .

1. The surface velocity may not be affected .
2. The surface velocity may be affected by the friction force , and its velocity may decrease according to some specific velocity . Here , the center of rotation will move along the line

between the original center of rotation i. e. the center of mass and the contact point . The specific location of the new center of rotation will depend upon the new velocity of the contact point . This represent a case of sliding and rotation .

3. The surface velocity may be affected by the friction force to the extent that the surface velocity tends to zero value . Here the center of rotation will move to the contact point and represent a case of pure sliding .

1 - INTRODUCTION

Shooting a ball with a spin has been used in almost all games that use ball as Basket Ball , Tennis , Squash , Foot Ball as well as others .

The Ball path trajectory and reflection angles from a wall or board is influenced by spinning .

The interst here is to investigate the mechanism the reflection angle of a Ball due to spinning with direct application on Basket Ball board .

A Basketball is throwen with the aim to fall in the basket ring . The ball may pass through the ring & score m it may hit this steel ring , or the board with the angle 0 1 . This reflection angle is the interest of this paper .

2 - METHOD AND ANALYSIS

If the velocity and angle of incidence are V1, and O1 and the velocity and angle reflection are V2 and O2 . There is the angular velocity in the plane of motion , m is the ball mass , I is the moment of inetria , u is the coeficient of friction between the ball and the basket board or the ring , as shown in Fig . 1 .

Interia Force = F = m (V2 - V1)

and befor reflection :

Fx = - F cos O1

Fz = - F sin O1