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DATA EXTRACTION USING KINOVEA FOR ACCESSIBLE ON-SITE BIOMECHANICAL ANALYSIS

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Abstract: *It is fairly difficult to talk about performance when, if we were to talk about assessment regarding human movement, we are lacking in accessible means of infrastructure, yet to also be valuable enough to make its difference. Of course, this would be a discussion about biomechanics, and even this can be split into two: data extraction and data analysis. This study will be concerned with the extraction of objective data from specific individuals, having only the most accessible means, and to be able to do this on-site. The equipment needed would be two mid-level cameras of at least 50 FPS capacity and white tapes to contrast the black marker as the passive attached markers on the subjects. The software used is Kinovea 9.5 and the extracted data is collected in Microsoft Excel. Once we have collected the data, the analysis can commence and it can be done a a wide variety of manners. To make everything more efficient, all the raw date can be introduced directly within a template created with various programing languages, like let's mention Python for one, and everything can be done directly through it. In this day and age, if we want to keep pace with the speed of how everything is done, we specialists must adapt too and learn new ways of how to improve our professional skill set.*

Rezumat: *Este foarte dificil să vorbim de performațe când nu avem infrastructură accesibilă și totodată suficient de valoroasă, pentru ceea ce vine înaintea rezultatelor în ceea ce privește mișcarea umană. Desigur aici e o discuție despre evaluarea biomecanică, iar aceasta la rândul ei o vom împărți în două porțiuni: culegerea datelor și analiza datelor. În lucrarea de față doresc să evidențiez prima parte și anume, de culegere a datelor și cum pentru această parte importantă, reușim să utilizăm echipanente accesibile și să extragem date obiective. În primul rând se va stabili pentru mișcarea evaluată un model determinist, urmând ca mai apoi să se stabilească logistica evaluarii. Mișcarea va fi înregistrată video, iar subiecții vor avea atașați niște marker pasivi ușurând astfel extragerea datelor ulterioară. Culegerea datelor este realizată prin utilizarea softului Kinovea 9.5 și introducerea acestora într-o bază de date, în cazul de față Microsoft Excel. Odată digitalizate rezultatele acestea, analiza propriu zisă poate decurge într-un mod divers. Pentru a eficientiza tot acest proces ulterior de analiză, limbaje de programare precum Python pot fi de un real folos. În present, dacă vrem să ținem pasul cu viteza cu care avansează totul, noi specialiștii trebuie la rândul nostrum să ne adaptăm și să învățăm mereu noi mijloace prin care să ne îmbogățim bagajul professional.*

INTRODUCTION

In this day and time in sports, fitness, physical therapy, and many other domains that focus on human movement the need of better, objective, dynamic and also accessible means are becoming a necessity (Mahadas, S., Mahadas, K., & Hung, G. K. 2018).

A group of 20 young adults were included in this study. They were all first-year students of physical education. The video materials were taken in one of their classrooms during a window between classes. They were all healthy and none reported injuries in the previous 6 months.

Angles to determine varum, valgus and neutral of the knee were taken from a sagittal plane. Flexum, recurvatum or neutral were also observed from a frontal plane. Height of jump was within the recorded distances taken. It is known that laboratory conditions are best when it comes to biomechanical analysis, only these techniques are disadvantageous in a sense in which they cost a lot, and that makes them rarely accessible, and even worse you cannot carry then on site, them being comprised of a lot of hardware. Thus, being the conditions, the applicability is severely impaired (B. Requena, F. Requena, I. García, E. S. S. de Villarreal, and M. Pääsuke 2012). Alternative means to get objective data need to be obtained in order to reach better conclusion, so better decision-making can be done (Ang CL, Kong PW 2013). We need to register lengths and displacements of specific points, time elapsed for specific actions, angles and so on. Using this very important data you can then get to more specific information like force, velocity, acceleration, work, power, torque and other such measures Liu J, Stewart H, Wiens C, Mcnitt-Gray J, Liu B 2022).

In the world of biomechanical analysis, laboratory conditions with sets of over 10 cameras all highly proficient with over 100 FPS in their characteristics are golden standard. However, these conditions are hard to apply in field work. It can get a very costly either to do the actual assessments in the lab, or to get a team of players (of whichever sports) to the lab, or both. Efforts are always appreciated whenever we can get objective data in dynamic assessment and the mail goal is to bring as qualitative conditions as possible on-site and take advantage of a more objective perspective.

Kinovea 0.9.5 is firstly a free software really user friendly, updated since the first editions appeared. It has the ability of being calibrated for framerate and does so automatically so you can have fairly accurate time output. It also can be calibrated length wise using a reference within the plane tested so you can get accurate lengths for whichever purpose in metric system (Paolino S, Zampa F 2023). The data obtained from the video analysis in the Kinovea software will then be introduced in a data set directly in an excel spreadsheet and furthermore analyzed.

The need for more objective data and it being close at hand and accessible in the field of human movement is becoming more and more of a necessity. The past experienced specialist, seasoned with training know-how and intuition, somehow does not produce as much valuable result in competitions today if they do not keep up in up-to-date assessment skill and base their decision making on the reliable data they can obtain (Van Hooren et all.2019).

I. METHODS

1.1. Subjects

In this study 20 subject took part, 10 males and 10 females. They were all healthy individual with no declared injury in the last months. They were all between 20 and 22 years of age range, and most have an active sports background. They were executed one vertical jump without having been warmed up or having been prepped before in what they will be doing prior to the jump. They were shown what to do, and given the parameters to follow and then executed one try of said jump.

1.2. Assessment tools and software

Two mirrorless Canon EOS M50, 24.1 MP, 4K, Black + attached lens EF-M 15-45mm f/3.5-6.3 IS STM set on fixed tripods at 1.50 m of the ground in a sagittal and frontal plane facing perpendicularly the subjects.

The passive markers on the subjects were place frontally and bilateral: on the most anterior part of the upper iliac crest, in the middle and right under the patella, middle aspect between the two malleoli in the talar-tibial joint (figure 1). And laterally the markers were places: the most lateral part of the iliac crest, greater trochanter, middle of lateral side of the knee joint, peroneal malleolus (figure 2). The markers consisted of white tape to contrast the black marker, thus making it easier for the software when the automatic tracking sequence commenced to follow the markers (Takeda, I., Yamada, A., & Onodera, H. 2020).

Figure 1. Markers - anterior view

Figure 2. Markers - lateral view

Because the software calibrates itself to a reference measure close to the subject, you do not have to be a precise to were you place the cameras. The subjects just need to be within videoframes and the markers visible. A vertical line of 25 cm was then used to calibrate the reference.

Kinovea 0.9.5 is the software used for the purpose of this study, and it is an updated version and pretty user friendly. It is an open-source software free to use. Even without previous training or work with this specific program, it is highly intuitive. It works pretty good even with lower quality 25 fps cameras, but of course if you want to limit error and get higher accuracy, the higher framerate, the smaller percentage in errors. Our cameras were 50 fps and the cameras were stabilized on tripod support to limit disturbances as much as possible (Balsalobre-Fernández, C., Tejero-González, C. M., del Campo-Vecino, J., & Bavaresco, N. 2014). It has been already useful in more instances of biomechanical analysis with other cameras and its reliability in correlation to other validated software has been proven (Nor Adnan, N. M, et all 2018), so we were eager to try and set up a road path in this direction.

1.3. Data extraction

Each recorded jump will be introduced in the Kinovea app, after which the app should be line calibrated accordingly to the measure of reference. Reference taken should be done so vertically. Data extracted for this study will export the frame notes regarding angles on the lowest part of the jump (figure 3), highest part of the jump (figure 4), and it does so to find out the varum or valgus nature of the knees for each lower limb.

Figure 3. Lowest angle - anterior view

Figure 4. Highest angle - anterior view

Additionally, it will register the information from the highest part of the jump respectively the standing part and get the height of jump (Puig-Diví A, Escalona-Marfil C, Padullés-Riu JM, Busquets A, Padullés-Chando X, Marcos-Ruiz D 2019) (figure 5).

From an anterior point of view when we take values of 180 we will be describing a neutral or 0 degrees deviation. If we were taking negative values, we convened those to be varum deviation, as for the positive to be valgus.

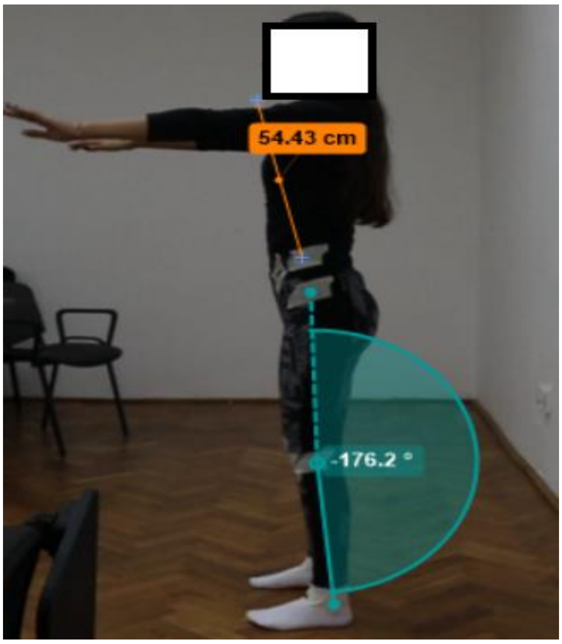

Figure 5. Length of jump

1.4. Database

Once the data was obtained an excel spreadsheet was created to better handle the situation afterward. First column had the initials of the subject. Second column contained the sex of the subject. All of the columns from C to F will take the knee angles of the subjects observed in a sagittal plane from a anterior point of view. Column C had the angle of the right knee checking for valgus or varus in the lowest point before the ascending point of the vertical jump. If it has deviated from 180 with a negative direction then it will represent varum and if it deviates in a positive direction then it will represent genu valgus (Rerucha CM, Dickison C, Baird DC. 2017). For the neutral position we will use 180. In column D we have the same notations in place only for the left knee. Column E will check out the right knee for deviation with the same negative representation for varum and positive for valgus and 180 for neutral. And in column F we observed and obtained data for the left knee. Column E and F will take into account the deviations for the point of maximum height within the jump.

The column G and H will check out the angles of the knees observed in a frontal plane from the left side point of view. Column G will note the level of flexion in the knees in the lowest moment of the eccentric phase of the pre-jump. H column will register the degrees within the knees in the highest point of flight mid-jump. And in the final I column, we can monitor the actual objective of a jump, and that will be the actual height of a jump (figure 6). On the highest point in column H, we also get to register some negative values. Those we interpret as genu recurvatum and the positive will have to mean genu recurvatum. For the 180 value the same neutral value is attributed.

Inițiale	Sex	Gen. min f	Gen. min f	Gen. max (	Gen. max (	Gen. profil	Gen. profil	Detenta
M.E.	m	171	179	174.9	171.4	91.5	-167.1	64.41
R.I.	m	162	-165.8	-170.2	169.8	121.2	166.2	45.15
V.M.	m	-179	-173.4	-179	175.4	107.7	176.3	49.31
K.J.	m	175	-175.8	177.2	170.6	99	174.8	58.39
D.A.	m	-148.1	-179.9	-177.4	-179.5	74.1	177.4	30.16
P.M.	m	175.8	-174.5	-172.6	-178.7	83.8	177.5	62.72
N.L.	m	-149.7	-152.8	-176.3	-179.3	109.4	-177.2	52.2
O.S.	m	-175.9	-168.8	-171.5	-179.2	100.4	170.3	53.87
A.J	m	-160.9	-163.9	-172.6	-174.4	104	168.7	45.86
L.P	m	-173.4	-171.1	177.9	179.1	113.6	-174.7	48.05
P.A.	f	-175.6	-175	180	-179.2	108.7	170.8	36.29
P.I.	f	-165	-170.2	-177.4	-175	101.9	178.2	57.73
B.S.	f	-171.5	164	180	-179.4	104	175.4	59.39
M..	f	159.4	171.1	173.9	174.5	103.8	179.7	42.3
T.E.	f	176.9	176.8	-175.3	-171.5	124.5	179.8	36.15
F.F.	f	169.9	174.3	-177.8	176.3	103.8	180	40.89
H.M.	f	177.6	-167.1	-176.6	-175.9	107.4	-177.5	54.43
N.L.	f	1755.5	177	176.6	173.3	104.2	-176.2	32.96
K.M.	f	167.4	168.3	174.5	178.5	117.4	176.6	35.65
H.D	f	-171	163.1	-174.3	177	115.8	-178.8	36.47

Figure 6. Data set

1.5. Data analysis

We tried having done a differentiation between male and female subject, when linked with the height of the jump. For that reason, we've isolated every joint in the lowest and highest part from a sagittal and frontal plane and tried verifying the annotations. We observed that male subjects are prone to go into a varum deviation on average bilaterally and in both observed phases, lowest respectively the highest, while the female part of the group tends to drift into the more valgus category

It is easier to visualize the angles going from 0 onward and deviating toward valgus or varum. But the software gives you the angles starting from a reference point of 180. We as specialists whom have served with goniometric tools can easily redress our point of view and see the 0–180-degree line as a neutral line and then alter from there in one direction or another. For instance, if we were to have for third column "Gen min față dreapta" meaning right knee – lowest point, in the second row we have a value of 162. That will translate in itself as 8 degrees valgus. The fourth column same row will have the negative value of 165.8. That will automatically translate into 4.2 degrees varum deviation. So, for the second subject in the lowest part pre-jump, we have bot valgus deviation for right knee and varum deviation for the left. It will be the same in before-last column in the highest point of the jump. Only negative values will mean recurvatum and the majority of them being positive will translate into genu flexum (Lazennec, J. Y., Chometon, Q., Folinais, D., Robbins, C. B., & Pour, A. E. 2016).

II. RESULTS

The outcome of the analysis in terms of height of jump as it can be simply observed is pretty even, with a bit of a lead from the male subjects, having an average of 51,01 cm for them over 43.23 cm for the female subjects. The distribution of values for knee deviation variates pretty wide but that maybe due to the small group of subjects observed. As we can observe in plot from figure 7, these male subjects from the first element in pre-jump mostly exercise the loading with a genu varum tendency, whereas the female subjects are more prone to a genu valgus approach.

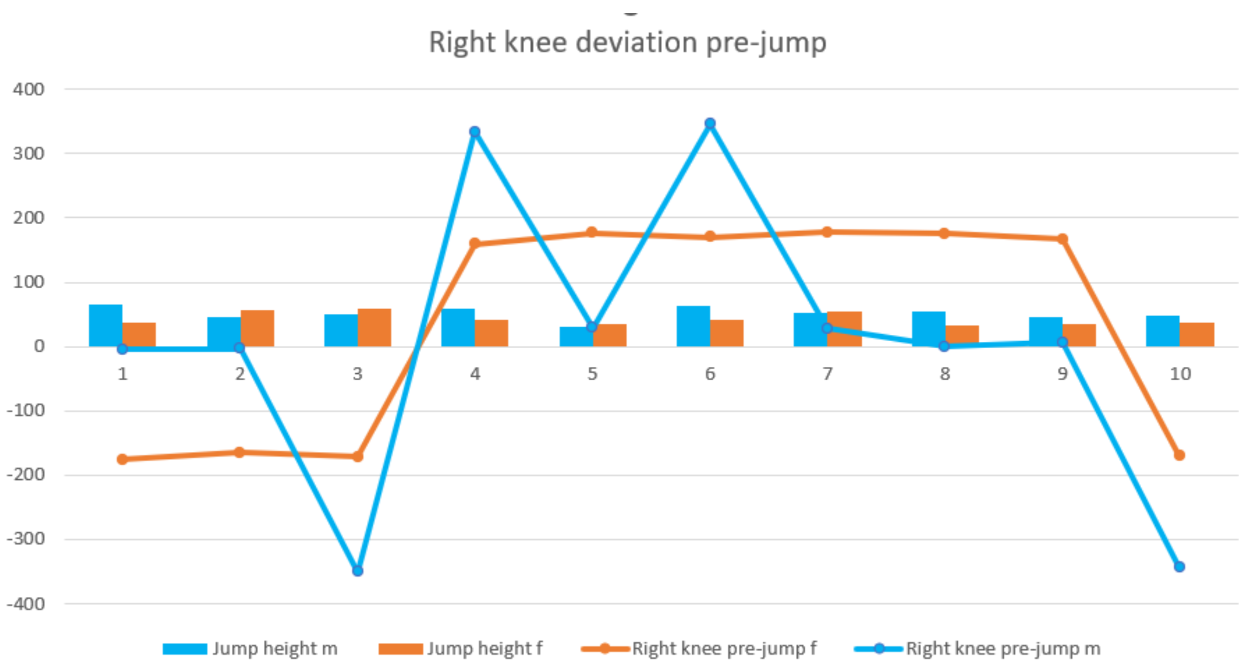

Figure 7. Right knee deviation pre-jump linked with height of jump

The genu varum tendency stays present during prejump within the male part of the group, and even during flight in the highest part of the jump.

In the lowest part of the lateral view observing the frontal plane all subject in the pre-jump loading phase for into flexion. Although we must mention that for male and average of 100.47, which means almost 90 degrees of flexion, with almost 10 degrees behind we have the females with a average of 81 degrees of flexion from starting position.

III. DISCUSSION

We can discuss the nature of the valgus and the hip implications on the medial and lateral deviation of the knees. The internal and external rotation of the hips will often generate medial and lateral deviation especially when in flexion. But this phenomenon is also attributed to different other aspects: like training for example and the means to access different muscle chain to reach an established goal; Culture, when from early on in development we guide population gait, mannerisms, wardrobe, tics etc. selectively to reflect somewhat the gender of the individual. It would be interesting to follow on within the interdisciplinary team of specialists and see what we can discover if we further our onlook on the matter. Earlier studies have also shown this tendency upon the intensity of an activity of women going into a valgus phase upon impact, and this might also be the cause for the high incidence of ACL injuries within the female population (Russell KA, Palmieri RM, Zinder SM, Ingersoll CD 2006).

Of course, having the analysis done in excel is a starting point but in future work we shall try and improve and raise the level of efficiency by having a helping hand from programing languages like python. Developing a framework through which if the infrastructure will be solid, any time a specialist will want to do more work in this sense, they will conserve a lot of time and energy. So whenever new data is introduced withing the data set, the output for said analysis can be more readily presented.

IV. CONCLUSIONS

This work should be viewed as a promising trial, and it encourages specialists to pursue this new path of extracting date, because as it has been observed it is highly accessible and it can obtain reliable data if the implementation is properly structured.

Although data extraction is one aspect of this paper, the limitation can be observed when it comes to data analysis. The data even for just a few subjects depends on the experience of the specialist who is viewing the data set. If a new data set occurs, new analyses should be taken and all computation should be undergone once more, and for big data sets that would consist of tremendous amounts of work.

For future interest and in the spirit of interdisciplinarity new approaches regarding data analysis using different means like programming languages such a Python will be pursued. The advantages would be immense time and cost wise, but also in terms of creating a new bridge between the field of human movement and all of what the new digital era has to offer.

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