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EPIDEMIOLOGY OF SPORTS INJURIES IN EUROPEAN UNION COUNTRIES

EPIDEMIOLOGÍA DE LAS LESIONES DEPORTIVAS EN PAÍSES DE LA UNIÓN EUROPEA

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ABSTRACT

Participation in sports promotes health and maintains good habits, but entails a risk of injury. The present article uses multivariate analysis to examine the relationship between type of injury, location of injury, sport (soccer, basketball, volleyball, gymnastics), county in which it was practiced and age, in five European Union countries. Knowledge of these relationships can be used to develop specific strategies to improve prevention and to reduce the injuries that occur.

KEY WORDS: Sports injuries. Epidemiology of sports. European Union. Prevention

RESUMEN

La práctica deportiva es una actividad que se recomienda para mantener y promocionar la salud y los buenos hábitos. Sin embargo puede acarrear un riesgo importante de lesiones. Este estudio presenta, mediante técnicas de análisis multivariante, la relación que existe entre la tipo de lesiones, lugares del cuerpo donde se producen, los deportes más populares; fútbol, baloncesto, voleibol, y gimnasia, edad y países donde se practica, tomando datos de cinco países de la Unión Europea. Si relacionamos estas características entre sí, podemos elaborar estrategias específicas al tipo de deporte y país donde se practica, con el objeto de mejorar la prevención y poder disminuir la cantidad de lesiones que se producen.

PALABRAS CLAVE: Lesiones deportivas. Epidemiología de las lesiones. Unión Europea. Prevención

INTRODUCTION

In recent years, there has been a substantial increase in the number of people who practice sport. Health organizations encourage people to practice physical activities regularly, because physical activity has a variety of beneficial effects on health and lifestyle.

Physical inactivity and a sedentary lifestyle in the European Union are associated with mortality and morbidity Pate R. R. et al (1995), low quality of life, (Leveille S. et al. (1999), Province M. A. et al (1995), Report: Physical Activity and Health (1996), Bijnen F. G. et al. (1999), Penninx B. W. et al. (1999)) and a high risk of obesity, diabetes, hypertension, coronary heart disease, osteoporosis, fractures, colon cancer, breast cancer, prostate cancer, psychiatric disorders and a high risk of hospitalization, (Rockhill B. et al., (1999), Moradi T. et al. (2000), WHO (1998), Sherman S. E et al. (1999), Giovannucci E. et al. (1998), Gillum R. E. et al. (1996), Slattery M. L. et al. (1997), Haapanen-Niemi et al. (1999)).

Physical activity is healthy, but carries with it the risks of injury, especially sports injuries, which have increased in recent years due to lack of training or lack of warming up. The most frequent injuries are dislocations, contusions, fractures, wounds and commotions and the parts of the body that are most frequently injured are the ankle, knee, shin and arms (Lindblad et al. (1992), Inklaar (1994), Kujala et al. (1995), Branche et al. (1997), Ellert-Petersson et al. (1997), Bostrom et al. (2001), Burt et al. (2001)). The increasing incidence of sports injuries is considered a public health problem, (Parkkari et al. (2001), Van Mechelen (1997)).

Garrido et al. (2009) recently studied the epidemiology of sports injuries, according to the sport played, sex, age, localization of the injury, type of injury and requirement for hospitalization.

In this article, we present the results of a multivariate analysis conducted to establish the relationship between sports injuries and affected body part, the most popular sports (football, basketball, volleyball and gymnastics), age, and playing countries, in a simple way. The data come from five European Union member states, completing a study conducted by Petridou et al. (2003).

This is a descriptive and multicentric study, and thus is not subject to the particular sociological characteristics of individual countries for this reason it is more representative of the European Union than a study of a single country.

Another feature of the work is that it is a study of sportsmen and sportswomen treated in emergency departments in five countries of the European Union, and thus it provides an estimate of the nature of the sports injuries that occur in non-professional sport, in people who practice sports in their free time; it is thus representative of the general population, and hence this report will be of interest to public health.

Studies using only absolute frequencies or proportions are limited.

This work used contingency tables, to study the relationship between sport, country, age, type of sports injuries and affected body part.

Moreover, by plotting the data obtained in this study, the information can be summarized and interpreted more easily.

The multivariate method used was the Factorial Correspondence Analysis. Based on the joint graphical representation of populations and characteristics of sports injuries, we aimed:

1.- To compare the characteristics of lesions (age, type of injury and affected body part) between established populations (country/sport).

2.- To evaluate the degree of similarity between the characteristics of the lesions.

3.- To evaluate the degree of association between the established populations and the characteristics of the lesions.

MATERIAL AND METHOD

The data used in this article came from a study by Petridou et al. (2003), Table 1, which examined the magnitude and characteristics of sport injuries using information obtained from emergency hospital services in five European countries: Denmark, France, Greece, Holland and the United Kingdom, in association with socio-demographic factors, injury characteristics and sport played. A common questionnaire was used under the coordination of the European Home and Leisure Accident Surveillance System (EHLASS).

C./Sport	DKf	FRf	GRf	NLf	UKf	DKb	FRb	GRb	NLb	UKb	DKv	FRv	GRv	NLv	UKv	DKg	FRg	GRg	NLg	UKg
Age (years)																				
15-17	439	32	155	2520	33918	111	49	306	680	2193	22	19	97	67	97	63	87	40	6700	482
18-24	1324	43	223	4200	53461	129	39	180	600	1561	87	12	24	122	137	77	19	33	1600	432
25-34	1306	31	198	4900	54914	36	11	84	480	959	65	2	7	183	390	32	0	26	500	138
35-44	477	6	71	1820	16474	17	2	12	160	271	26	1	4	153	176	23	0	19	200	60
>45	206	1	12	560	2746	10	0	4	80	35	7	1	4	85	78	46	0	12	1000	60
Type of injury																				
Contusion/ Abrasion	1077	44	279	4480	79303	71	55	209	560	2520	55	17	58	159	374	47	55	70	3900	477
Open wound	199	8	53	700	11467	18	6	31	120	281	5	1	2	6	32	4	5	2	300	50
Fracture	477	16	121	3080	22773	47	12	85	360	793	23	3	17	98	179	30	9	12	2200	182
Dislocation/ Distortion	1613	40	185	4480	35371	146	23	251	800	1134	108	13	54	281	244	116	34	42	2700	413
Concussion	34	2	11	140	2100	1	1	6	0	15	0	0	6	0	0	0	2	2	100	0
Other	353	4	11	1120	10498	19	3	4	160	276	17	2	0	67	49	45	2	0	800	50
Injured body part																				
Head/Face	293	16	75	1260	17766	32	9	41	200	422	6	3	7	18	32	9	14	5	600	0
Fingers	251	6	22	980	13406	110	33	95	560	1305	62	14	45	140	276	21	8	2	1600	117
Arm	540	15	144	2240	26165	20	13	106	220	903	7	6	28	61	147	43	18	16	2500	182
Ankle	900	36	181	3780	40055	79	29	253	680	1486	62	7	39	256	244	61	29	37	2800	313
Knee	807	17	108	2100	20674	29	11	48	140	296	19	3	9	49	32	29	8	23	800	131
Other lower limb	833	14	85	2940	32464	24	4	23	140	437	23	1	6	67	114	55	10	28	1300	116
Trunk	128	9	43	700	10983	8	2	19	60	171	6	1	2	18	32	24	18	16	600	313

Table 1. Frequency of sports injuries, according to age, type of injury and affected body part.

We considered 20 populations, defined by country and type of sport as shown below.

	Football	Basketball	Volleyball	Gymnastics
Denmark	DKf	DKb	DKv	DKg
France	FRf	FRb	FRv	FRg
Greece	GRf	GRb	GRv	GRg
Holland	NLf	NLb	NLv	NLg
United Kingdom	UKf	UKb	UKv	UKg

We also considered three different categories: age with five levels (between 15 and 17 years, between 18 and 24 years, between 25 and 34 years, between 35 and 44 years and above 44 years), type of injury (contusion-abrasion, open wound, fracture, dislocation-distortion, concussion and other injury) and injured body part (head and face, fingers, arm, ankle, knee, other lower limb and trunk).

We constructed three frequency tables of populations and characters, one for each of the categories (age, type of injury and injured body part), based on the percentages and simple sizes reported in Table 3 of Petridou et al. (2003).

If we have *p* populations and *q* characters *($q \le p$)*, f_{ij} is the frequency of character *j* in the population *i*, $f_{i.}$ is the frequency of population *i*, $f_{.j}$ is the frequency of character *j* *($i=1,\ldots,p$; $j=1,\ldots,q$)*.

Representation of populations

The Chi-square distance with respect to *q* characters between two populations *i, i'*, is equivalent to the usual Euclidean distance between *p* points of R^q:

$$P_i = \left(\frac{f_{i1}}{\sqrt{f_{.1}}\, f_{i.}}, \ldots., \frac{f_{iq}}{\sqrt{f_{.q}}\, f_{i.}} \right)$$

We can consider that the data matrix is the matrix *X*

$$X = \left(\frac{f_{ij}}{\sqrt{f_{.j}}\, f_{i.}} \right)_{pxq}$$

In a Principal Component Analysis (PCA), we can represent the rows of the matrix *X*, in dimension *d* giving the new coordinates of the populations.

How the eigenvectors of the covariance matrix of *X* are equals to eigenvectors of the matrix $X'D_pX$, being $D_p = diag.(f_{1.},\ldots.,f_{p.})$. We diagonalize the matrix $X'D_pX$,

$$X'D_pX = TD_\lambda T'$$

$$(T \;\; orthonormal \quad D_\lambda = diag.(1, \lambda_2, \ldots., \lambda_q) \quad 1 > \lambda_2 \ge \ldots \ge \lambda_q)$$

If λ_t is the lowest eigenvector greater than zero, the coordinates of the populations are given by the 2^{nd}, 3^{rd},…, *t-th* column of the matrix *A=XT*.

If we represent the population by the columns 2^{nd}, 3^{rd},…, *d-th*, $d \le t$, the percentage of variance explained by the axes 2^{nd}, 3^{rd},…, *d-th*, is:

$$P = 100 \frac{\lambda_2 + \ldots.. + \lambda_d}{\lambda_2 + \ldots.. + \lambda_q}$$

The representation in dimension *2 (d=2)* gives a representation of populations, separated by the Chi-square distance, except the loss of information produced when we reduce the dimension by PCA.

Representation of characters

The Chi-square distance between two characters *j, j'* according to the *p* populations is equivalent to the Euclidean distance between the *q* points of R^p:

$$Q_j = \left(\frac{f_{1j}}{\sqrt{f_{1.}\, f_{.j}}}, ..., \frac{f_{pj}}{\sqrt{f_{p.}\, f_{.j}}} \right)$$

We can consider that the data matrix is the matrix $\tilde{X}'$, of *q* rows and *p* columns.

$$\tilde{X} = \left(\frac{f_{ij}}{f_{.j}\sqrt{f_{i.}}} \right)_{pxq}$$

If we conduct a Principal Component Analysis (PCA), we can represent the rows of the matrix $\tilde{X}'$. The result gives the new coordinates of the characters in dimension *d*.

How the eigenvectors of the covariance matrix of $\tilde{X}'$, are equals to eigenvectors of the matrix $\tilde{X} D_q \tilde{X}'$ being $D_q = diag.(f_{.1}, \ldots, f_{.q})$.

We diagonalize the matrix $\tilde{X} D_q \tilde{X}'$

$$\tilde{X} D_q \tilde{X}' = \tilde{T} D_\mu \tilde{T}'$$

$$(\tilde{T}\ \ orthonormal \quad D_\mu = diag.(1, \mu_2, ..., \mu_p) \quad 1 > \mu_2 \geq ... \geq \mu_p)$$

If μ_t is the lowest eigenvector greater than zero, the coordinates of the populations are given by the *2nd, 3rd,…, t-th* column of the matrix $B = \tilde{X}'\tilde{T}$,.

If we represent the population by the columns *2nd, 3rd,…, d-th, d≤t* , the percentage of variance explained by the axes *2nd, 3rd,…, d-th*, is:

$$P = 100 \frac{\mu_2 + ... + \mu_d}{\mu_2 + ... + \mu_p}$$

The representation in dimension *2 (d=2)*, gives a representation of characteristics, separated by the Chi-square distance, except the loss of information produced when we reduce the dimension by PCA.

The eigenvalues satisfy: $1>\lambda_2 = \mu_2 \geq \ldots \geq \lambda_t = \mu_t$

There is a relationship between the *A* and *B* matrix.

The *h-th* coordinate, $1 \leq h \leq d$, of character *j* and population *i*, is expressed respectively, in function of the depending on the *h-th* coordinate of the *p* populations and *q* characteristics, respectively, as:

$$b_{jh} = \frac{1}{\sqrt{\lambda_h}} \left(\frac{f_{1j}}{f_{.j}} a_{1h} + \ldots + \frac{f_{pj}}{f_{.j}} a_{ph} \right) \qquad a_{ih} = \frac{1}{\sqrt{\lambda_h}} \left(\frac{f_{i1}}{f_{i.}} b_{1h} + \ldots + \frac{f_{iq}}{f_{i.}} b_{ph} \right)$$

Therefore we can represent the coordinates of the populations and the characters, with reference to the same axes, known as factorial axes.

<u>Test of complete independence</u>

If there is stochastic independence between characters and populations:

$$p_{ij} = p((population\_i) \cap (character\_j)) = p(population\_i)\,p(character\_j)$$

then $N(\lambda_2 + \ldots + \lambda_q) \sim \chi^2$ with *(p-1)(q-1) degree of freedom.* being $N = \sum_{i=1}^{p} \sum_{j=1}^{q} f_{ij}$.

How the eigenvalues greater than or equal to zero, to contrast the stochastic independence between populations and characters is equivalent to the hypothesis:

$$H_0 : \lambda_2 = \ldots = \lambda_q = 0$$

If we accept H_0: all populations are distributed equally over the characters the representation does not make sense.

For more details of this methodology, see Cuadras (1991), Greeenacre et al. (1994) and Lebart et al. (1995).

The calculations were performed using the statistical software R (ca Package), Nenadi´c et al. (2007).

RESULTS

Petridou et al. (2003) published a table reporting the results of a survey of medically attended injuries in emergency services in five countries (Denmark, France, Greece, Holland and United Kingdom) using a common questionnaire.

The studied table is divided into three sections corresponding to age, type of injury and injured body part. For every table we have three data matrices *X.* For every table *X* we calculated the eigenvalues of the matrix $X'D_pX$, transposed data matrix multiplied by diagonal matrix whose elements are the frequencies of rows multiplied by data matrix.

The first section of the table shows us injury frequencies for different ages, nationalities and type of sport. In this section we have *20* populations (country-sport) and *5* characters *(15-17 years,* [15-17], *18-24 years,* [18-24], *25-34 years,* [25-34], *35-44 years,* [35-44], and *over* 44 *years,* (45,-)*).* In this case *p=20; q=5.*

The eigenvalues and the cumulative percentages of variance accounting for the factorial axes are:

$$\begin{array}{llllll} eigenvalues: & \lambda_1 = 1; & \lambda_2 = 0{,}085; & \lambda_3 = 0{,}012; & \lambda_4 = 0{,}001; & \lambda_5 = 0{,}000 \\ percentage & & 86{,}13\% & 12{,}21\% & 1{,}31\% & 0{,}35\% \end{array}$$

The total Chi-square is:

$\chi^2 = 201560(0{,}085+0{,}012+0{,}001+0{,}000)=19752{,}88$ with *76 degrees of freedom (p<0000).* This χ^2 is statistically significant, and therefore we can conclude that there is a dependence between the populations and characters and thus that there is a relationship between countries and types of sport and age of people's injuries.

These associations are plotted in Figure 1. The first two axes of the Correspondence Analysis explain (cumulatively) *98,34%* of the variance, and thus we deem the two-dimensional solution and solution of Figure 1 adequate.

From the graphical representation we can see that there are four groups of populations (countries-sports) according to the ages of people injured.

Group I: This group consists of "countries/sports", in which injuries are associated with the age group [15-17]. This group includes peoples who play basketball, regardless of country, people who play volleyball in France and those who practice gymnastics in the United Kingdom.

Group II: This group consists of "countries/sports" in which injuries are associated with three age groups {[18-24] [25-34] [35-44]}. This group includes peoples who play football, regardless of the country and people playing volleyball in Denmark and the United Kingdom.

Group III: This group consists of “countries/sports”, which injuries are associated with the age group (44, -). This group includes people who practice gymnastics in Denmark and Greece and volleyball in the Netherlands.
Group IV: This group includes peoples who practice gymnastics in Holland and France and volleyball in Greece. Injuries in this group are more frequent among the youngest and the oldest.

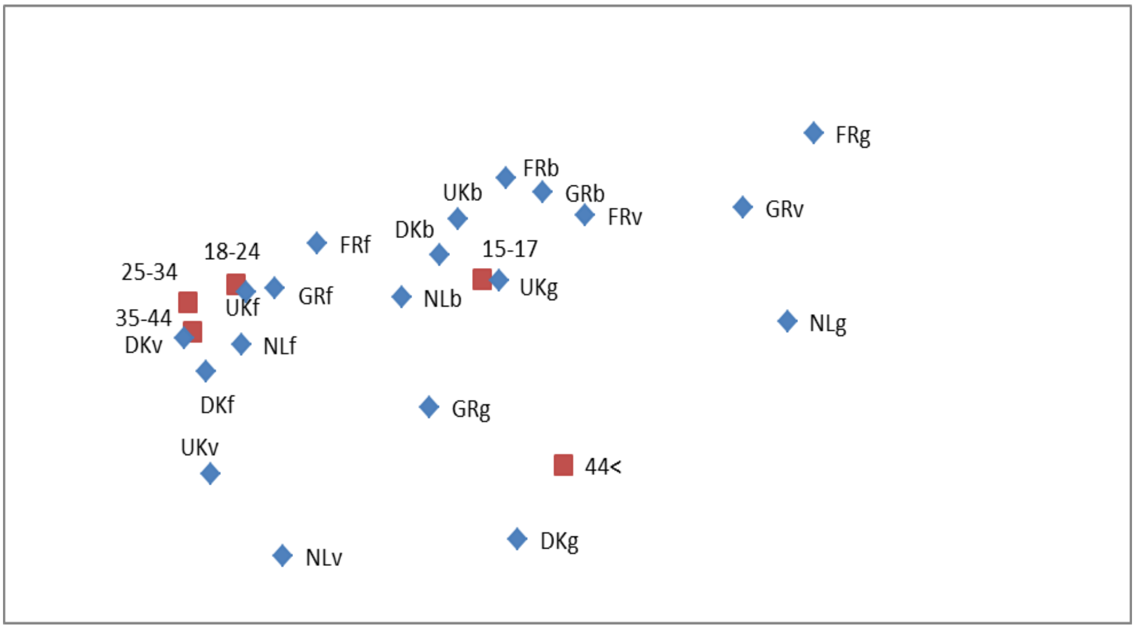

Figure 1. Correspondence between people in 20 populations (5 nationalities and 4 types of sport) and 5 age groups: *(15-17 years,* [15-17]. *18-24 years,* [18-24]. *25-34 years,* [25-34]. *35-44 years,* [35-44]. *over* 44 *years,* [45,-)

The second section of the table shows us the frequency of different type of injury in different nationalities and sports. In this case we have *20* populations (country/sport) and *6* characters *(contusion-abrasion, open wound, fracture, dislocation-distortion, concussion and other injury).* In this case *p=20; q=6.*

The eigenvalues and the cumulative percentages of variance accounting for the factorial axes are:

$$\begin{array}{lllllll} eigenvalues & \lambda_1 = 1; & \lambda_2 = 0{,}021; & \lambda_3 = 0{,}003; & \lambda_4 = 0{,}001; & \lambda_5 = 0{,}000; & \lambda_6 = 0{,}000 \\ percentage & & 79{,}37\% & 12{,}87\% & 3{,}99\% & 2{,}44\% & 1{,}33\% \end{array}$$

The total Chi-square is:

$\chi^2 = 201560(0{,}021+0{,}003+0{,}001+0{,}000+0{,}000) = 5039$ with *95 degrees of freedom (p<0,000).* This χ^2 is statistically significant, and therefore we can conclude that there is a dependence between the populations and characters and thus that there is a relationship between countries and types of sport and a types of injury.

These associations are plotted in Figure 1. The first two axes of the Correspondence Analysis explain (cumulatively) *92,24%* of the variance, and thus we deem the two-dimensional solution and solution of Figure 1 adequate.

From the graphical representation we can see that most countries/sports, are associated with dislocation-distortion, except:

In France, basketball is associated with open wounds. In the United Kingdom and Holland, volleyball and gymnastics respectively are associated with fractures. In the United Kingdom, football and basketball are associated with contusion/abrasion. In Greece, football is associated with other injuries.

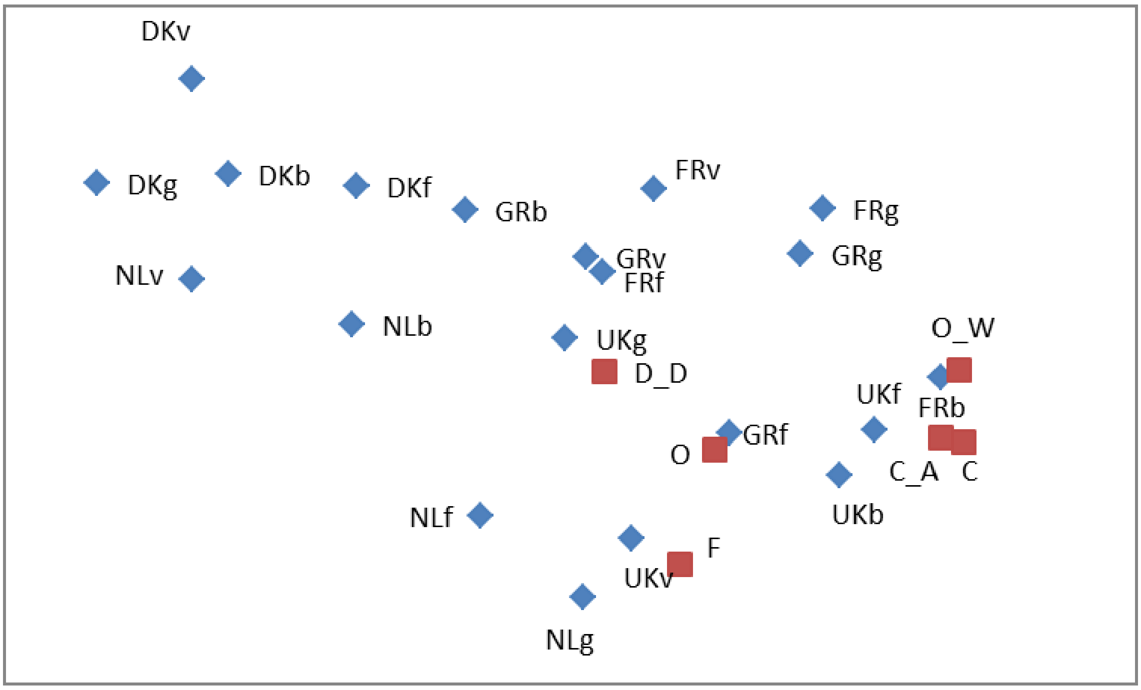

Figure 2. Correspondence between 20 populations (5 nationalities and 4 types of sport) and 6 characters *(Types of injury: contusion/abrasión: C_A, open wound: O_W, fracture: F, dislocation/distortion: D_D, concussion: C, other injury: O)*

The third section of the table shows us the injury frequencies for different injured body parts, nationalities and types of sport. Here we have *20* populations (country/sport) and *7* characters *(head and face, fingers, arm, ankle, knee, other lower limb and trunk).* In this case *p=20; q=7.*

The eigenvalues and the cumulative percentages of variance accounting for the factorial axes are respectively:

$$\lambda_1 = 1;\ \lambda_2 = 0{,}030;\ \lambda_3 = 0{,}006;\ \lambda_4 = 0{,}003;\ \lambda_5 = 0{,}002;\ \lambda_6 = 0{,}001;\ \lambda_7 = 0{,}000$$

$$71{,}23\% \quad 13{,}68\% \quad 6{,}93\% \quad 4{,}97\% \quad 2{,}16\% \quad 1{,}03\%$$

The total Chi-square is:

χ^2=201560(0,030+0,006+0,003+0,002+0,001+0,000)= 8465,52 with *120 degrees of freedom (p<0,000).* This χ^2 is statistically significant, and therefore we can conclude that there is a dependence between the populations and characters and thus that is a relationship between countries and type of sport and injured body part.

These associations are plotted in Figure 3. The first two axes of the Correspondence Analysis explain (cumulatively) *84,91%* de of the variance, and thus we deem the two-dimensional solution and solution of Figure 1 adequate.

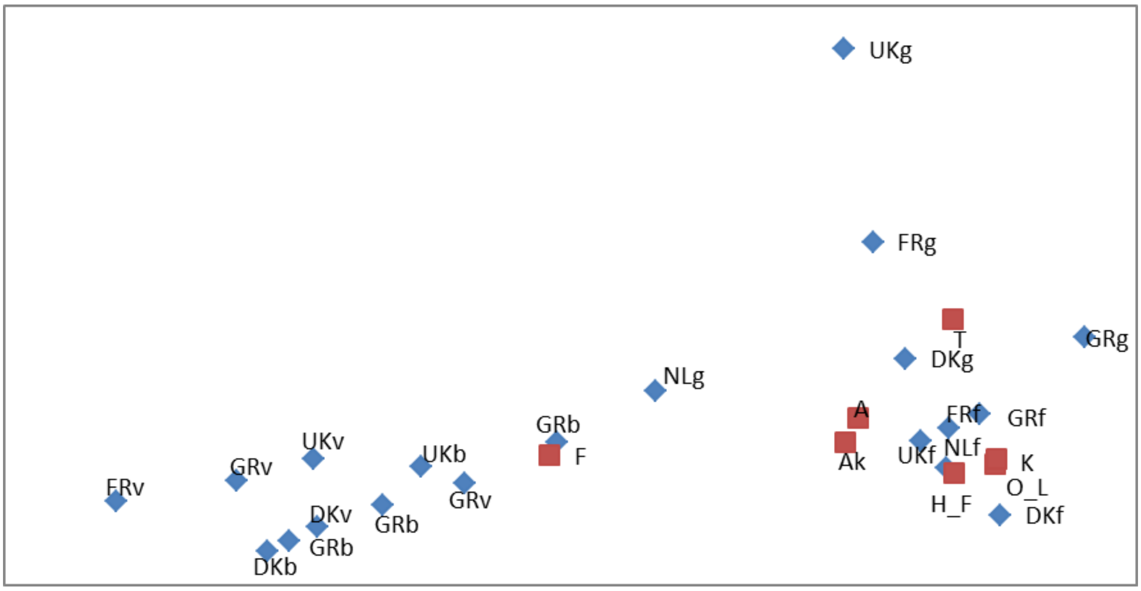

Figure 3. Correspondences between 20 populations (5 nationalities and 4 types of sport) and *7* characters *(head and face: H_F, fingers: F, arm: A, ankle: Ak, knee: K, other lower limb: O_L and trunk: T)*.

From the graphical representation we can see that countries and sports are closely related to the injured body part.

Basketball and volleyball are associated with finger injuries. Gymnastics is associated with injuries to the trunk. Football is associated with injuries to the arm, knee, ankle and other parts of the leg.

DISCUSSION

Based on the pattern of injuries by age observed in Figure 1, injured people aged between 25 and 34 years are typically those who play football and injuries that occur between 15 and 17 years are typical of those who play basketball. This reflects the fact that basketball is practiced more frequently in schools, while football is practiced from adolescence to adulthood age [25-34 years] and logically age increases vulnerability to injury. Injuries in those aged over 44 years in Denmark and Greece are characteristics of people who practice gymnastics. This reflects the fact that at this age and in these countries many individuals practice athletics, especially running. In the U.K., gymnastics injuries are associated with the 15-17 years old age group, the age when chiefly girls practice rhythmic gymnastics.

From Figure 2 we can conclude that, in all countries except for the U.K., volleyball is associated with injuries dislocations-distortions. In the UK it is clearly associated with fractures. Except in the U.K. and in France, where it is clearly associated with open wounds, basketball is also associated with dislocations-distortions. This can be attributed to the accelerations and decelerations, jumping movements and sudden changes in direction that are made in this sport.

Football is not clearly associated with any type of injury. In the U.K. injuries are associated with contusion-abrasion. In Greece football injuries are associated with “other injury”. In the Netherlands, football is associated with fractures and “other injury”. These characteristic football injuries have already been described by Fried et al. (1992) and Francisco et al. (2000) and reflect the fact that football is a contact sport.

Gymnastics includes a wide range of activities and both boys and girls practice this sport thence the injuries associated with gymnastics are diverse.

However, except in the case of Netherlands, where this sport is associated with fractures, gymnastics has a tendency to be associated with dislocations-distortions. This type of injury is frequently associated with rhythmic gymnastics, Terras et al. (2011).

Figure 3 reveals that basketball and volleyball are associated with injuries to the fingers. Football is associated with lower extremity injuries (ankle, knee and other lower limb) and arm injuries.

Gymnastics is associated with trunk injuries, probably in the lumbosacral area, Terras et al. (2011).

This study has demonstrated that the type of sport is strongly associated with the part of the body to which the injury occurs and that this is true in all countries. Therefore if a preventive measure practiced by a country is positive, this measure can be practiced in other countries.

CONCLUSIONS

- This study used a graphical approach to summarize and interpret injuries in different countries and different sports, using a classical method of representation (Correspondence Analysis). The results have allowed us to summarize and interpret the information.

- Injuries, in people aged 25 and 34 years old, are most often associated with football, probably because this is the sport that is most frequently played during leisure time at these ages.

- Injuries, in peoples aged between 25 and 34 years old, are most often associated with basketball, probably because this sport is mainly played by schoolchildren.

- Football and gymnastics are associated with all types of injuries, because football is a contact sport and gymnastics comprises a range of physical activities.

- Injuries to the lower extremities are associated with football. Finger injuries are associated with basketball and volleyball and injuries to the trunk, probably in the lumbosacral region, are associated with gymnastics.

- Finally, although the study was carried out on countries within the European Union with similar cultures and ethnicities, other features such as sports facilities, promotion of specific sports, etc.., mean that the types of injury, body parts injured and ages at which they occur can differ from one country to another within the same sport.

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