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Disparities in Motor Competence between Roma and Non-Roma Children in Croatia and Relations of Motor Competence, School Success and Social Economic Status

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Abstract The purpose of this study was to investigate possible differences in the development of motor skills between native and Roma children in Northern Croatia, but also to establish relations of motor skills, school success and socioeconomic status. The sample of 114 children (57 Roma) of both gender (55 boys) were assessed by *MABC-2*. *Social economic status* was represented by the mother highest level of education, and *grade point average* represented academic success. Regarding motor performance 9 children fall in the categories of *"motor impairment"* or *"risk for impairment"*, 7 of them were Roma minority. MANOVA *(gender) x (ethnicity)* was applied on *manual dexterity, aiming and catching and balance* and *total standard score* and both effects were significant (p=.000). Further univariate ANOVA's showed that the girls were better in *manual dexterity* (p=.000) and the boys in *aiming and catching* (p=.000). Non-Roma children performed better in *manual dexterity* (p=.000), *balance* (p=.000); and *total test score* (p=.000). *Manual dexterity* and *ethnicity* significantly (p=.000) predicted school success. Motor competence in Roma children was less developed than in native children. Poverty, parental-social but also environmental factors, significantly influence children's motor development.

Keywords Young School-age Children, Motor Competence, MABC-2, Ethnic Differences, Gender Differences, School Success

1. Introduction

Positive and successful movement experience is critically important for every child's life. Children learn by exploring their environment through movement [1]. Regular participation in movement and play activities may also lead to proficiency in motor skills, which in turn may affect future involvement in sports or physical activities and potentially preserve healthy body weight. There is also evidence that movement and physical activity may promote social success of the child and enhance academic achievement [2-4]. School age children, who evidence automaticity in motor skills, may have greater processing capacity available to learn more complex concepts, including symbolic representations of letters and numbers [5]. Namely, it seems that physical exercise has positive influence on executive functions [6] i.e. cognitive processes necessary for goal-directed cognition and behavior which develop across childhood and adolescence [7].

Proficiency levels of one's motor abilities and motor skills constitute motor competence [8], i.e. mastery of physical skills and movement patterns that enable enjoyable participation in physical activities [9]. White [10], suggested that competence is gained through interaction with environment, through playful and exploratory activities that ''show direction, selectivity, and persistence in interacting with the environment'' (p. 113).

However, indications occur pointing to interculturally different development of the motor competence, assuming traditional roles for boys and girls, which is implemented in child-rearing practices from early age. Gender differences in behavior may partly arise from differences in toys with which boys and girls tipically play, and parents socialize gender-typed behavior by selecting different toys and activities for boys or girls which may leads to different pattern in children's behavior [11]. Usually, the boys are found to be generally more motor skilled than the girls [12, 13].

Except gender differences, other culture related differences may be observed. Quah [15] proposed that parents from different ethnic backgrounds, and different levels of formal education, differ significantly in their

parenting styles. Booth et al. [16] found relationships between object control proficiency and socioeconomic status, but also that gender and ethnic differences can influence proficiency in object control skills. Similarly, Pate et al [17] quoted several studies, where the associations among race/ethnicity, gender, socioeconomic status, and health outcomes were well established, they also pointed out that race/ethnicity and socioeconomic status may modify fitness performance.

The Roma children have traditionally been disadvantaged in many cultures [18, 19]. Poverty and common social exclusion of that ethnic group largely determine child's academic success, while school deprivation and residential segregation may also cause underdevelopment of motor skills. Tsimaras et al. [20] reported that Greek-Roma children (7-10 yrs) performed significantly poorer in locomotion skills, handling skills and general motor ability. Equivalently, Zsidegh et al. [21] found that Hungarian-Roma boys (7-14 yrs) were significantly inferior in running, while Semoglou et al. [18] found that Greek-Roma preschool children significantly underachieved in visual motor integration, but not in the gross motor skills.

2. Objectives

Since the interrelations of ethnicity and motor competence in children were not investigated in Croatia, the aim of the present study was to evaluate possible differences in motor competence among Roma and native children in Croatia and to determine whether motor skills, along with the ethnicity and SES influence school success.

3. Materials and Methods

3.1. Sample

One third of all Croatian Roma population live in the Medjimurje County in the Northern Croatia, while all the other regional Roma communities are incomparably smaller. The sample of 114 children was drawn from two primary schools with the largest concentration of Roma children in the country. Children were equally distributed between Roma (n=57) and non-Roma ethnicity (n=57), 55 of them were boys and 59 girls. Age range of the children was 7 yrs and 9 months up to 10 yrs and 8 months, with a mean age of 8.27 yrs (± .77). After informal meeting with the children, teachers and principals, they all expressed their agreement with the involvement in the study, and signed consents were obtained from the parents while children gave their oral assent. At the time of the assessment all the children were healthy and without known neurological or other dysfunctions.

3.2. Measures

We used the second edition of the *Movement Assessment Battery for Children age band 2* (MABC-2) [22], which is a norm-referenced test comprising three age bands (3–6 years; 7–10 years; and 11–16 years) and consisting of eight motor items in each age band. MABC-2 is widely accepted tool in clinical and research community which assess three motor performance areas – *manual dexterity* (3 items), *aiming and catching* (2 items) and *balance* (3 items). The *manual dexterity* tasks include *placing pegs into a board*, *threading lace*, and *drawing a line* on a provided template. *Aiming and catching* tasks demands to throw a tennis ball to a wall and caught it with the hands with one bounce off/on the floor (7- and 8-year old) or directly without a bounce (9- and 10-year old). In the *aiming* task the child is requested to throw a beanbag onto a mat which is lying horizontally on the floor, 1.8 meters away. *Balance* tasks include *one-leg stand* on a balance board, *heel-to-toe walking* on a straight line and performing five successive *hoops* from one mat to another.

Except *aiming and catching*, all the tasks contains two trials and the best of two are rated. Aproximatelly 20 minutes were needed to assess one child. Provided norms allows *standard scores* for each item, *component standard scores* and *total standard score*. Since authors stated that the main purpose of the MABC-2 is identification of mild-to-moderate movement difficulties *(i.e. Developmental Coordination Disorder; DCD)* the test also allows to classify the subjects as *normal developing*, in the *risk for impairment*, and *motor impaired*.

Social economic status (SES) is ussualy determined by selecting the parental levels of education and/or income category. We adopted *Entwisle* and Astone [23] (p. 1526) stand of maternal education as a "human capital" in the home and used the mother highest level of education as an index of SES. The data were coded numericaly and the highest obtained level of the variable was used to represent socioeconomic status of the child. Four categories of data are formed: 1) not completed compulsory school (n=33), 2) completed compulsory school (n=29), 3) completed high school (n=46), 4) college education (n=6).

Academic school success was represented by *grade point average (GPA)* i.e. as cumulative average of all the grades in academic subjects and contained five levels.

4. Results

According to the percentile norms, stated in the manuals of the MABC-2, 4 children (3.5%) fall in the category of *motor impairment* while another 5 children (4.4%) fall in the *risk for impairment*, of those 9 altogether, 7 were Roma minority. Component standard scores are shown in Table 1.

Table 1. Mean values of MABC-2 component standard scores and total standard score

		MD		AC		B		TSS	
	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Girls Roma	31	10.00	2.88	9.45	3.43	9.23	3.61	9.48	3.21
Boys Roma	26	7.85	2.65	10.54	3.20	9.73	3.46	8.69	2.38
Girls Non-Roma	28	12.25	2.35	8.96	3.46	12.18	3.16	11.5	2.73
Boys Non-Roma	29	10.48	2.73	12.17	2.54	11.69	2.51	11.86	2.45
Total	114	10.18	3.04	10.27	3.38	10.69	3.42	10.4	3.00

MD - manual dexterity; AC - aiming and catching; B - balance; TSS - Total standard score;

To test the influence of the independent variables of ethnicity and gender on motor skills, a MANOVA 2 (gender) x 2 (ethnicity) was applied with three component standard scores (manual dexterity, aiming and catching, balance) and total standard score as dependent variables. Usual assumptions of MANOVA, like multivariate normality, Mahalanobis distances and multicolinearity were checked, and no violations were found. Box's test of equality of covariance matrices, as well as Levene's test, were not significant.

MANOVA revealed significant effects of *gender* (*Wilks' Lambda*=.729, F(4,107)=9.956, p=.000, η^2_p =.271) and *ethnicity* (*Wilks' Lambda*=.754, F(4,107)=8.729, p=.000, η^2_p =.246). Subsequent *ANOVA* analysis showed that the girls were better in *manual dexterity* F (1,110) =15.350, p=.000, η^2_p =.122) while the boys outperformed girls in *aiming and catching* F(1,110)=12.935, p=.000, η^2_p =.105).

Also, non-Roma children performed better then Roma children in *manual dexterity* (F (1,110) = 23.840, p=.000, η^2_p = .178), *balance* (F (1,110) =16.565, p=.000, η^2_p =.131); and *total test score* (F(1,110) = 25.610, p=.000, η^2_p =.189).

Further posthoc analysis using *Bonferroni criteria* showed that regarding *manual dexterity* native girls outperformed both, Roma boys (p=.000) and Roma girls (p=.01), while Roma girls were still significantly better then Roma boys (p=.018). Other differences were not significant.

Posthoc for *aiming and catching* revealed that native boys scored significantly better than both, Roma girls (p=.008) and native girls (p=.001). Roma boys didn't differ significantly from neither of groups.

In *balance*, Roma girls didn't differ from Roma boys. However, native girls were better than Roma girls (p=.004) and Roma boys (p=.034), while native boys were better than Roma girls (p=.022). We also checked whether the academic *school success* is influenced by the level of *motor competence* or by the *ethnicity* or *socioeconomic status* (SES). Ordinal regression analysis was performed on the output (dependent) variable of the *GPA,* which was ordered in 5 categories. In the first run we included *MABC-2 total standard score, SES, gender* and *ethnicity* as predictors. The analysis revealed that *MABC-2 total standard score* and the *ethnicity* significantly predicted *GPA* but, *gender*, and surprisingly, *SES,* did not. Although *MABC-2 total standard score* was significant, we wanted to examine influence of *manual dexterity* on the model by subtracting it from *MABC-2 total standard score.* After removal of *manual dexterity, total standard score* was no more significant. In final run, we included only *MD standard score* and *ethnicity* in the analysis. The predictors significantly accounted for moderate proportion of variance in outcome - Nagelkerke R^2=.341; likelihood ratio χ^2 (2) =43.695, p< .001.

The model showed systematic effect in *GPA* related to the *manual dexterity* and to the *ethnic* group. Both significantly predicted *GPA* (p=.000). Regarding to the *manual dexterity* the coefficient was .260 (SE=.068, p<.001), by taking the exponent we get odds ratio (OR) of 1.3, which indicates that odds of having higher *GPA* increases by 1.3 for each unit increase in *manual dexterity*. Also, the significant positive coefficient of *ethnicity* 1.646 (SE=.414, p<.001) indicated, in OR terms, that non-Roma children are 5.19 times more likely to have higher grade than Roma children.

5. Discussion

The study primarily attempted to identify differences between Roma and non-Roma children in motor competence and also to establish relationships between motor skills, ethnicity, socioeconomic status and school success.

We found that 7 (12.3%) out of 57 Roma children were classified in the categories of *motor impairment* and *risk for impairment*. In non-Roma sub-sample only 2 children (3.5%) were in the *risk for impairment* category.

Prevalence of motor impairment (DCD) varies across studies/countries, i.e. according to [24] there is 6 % in USA, 2% UK [25], 5.4% in Greece [26] and 4.5 % in Norway [27].

Gender differences were not surprising, but their marked conjunction with ethnicity is what is noticeable the most. Native children did not differentiate in manual dexterity but they outperformed Roma boys and girls significantly. Non-Roma boys scored significantly better in aiming and catching than both girl groups. In balance, again, native children scored better than Roma minority. Crespo et al. [28] (2013) allege that in nearly all of the reviewed pediatric studies, boys were more active than girls. For the specific age group of 6-11 year-olds, which is in compliance with the current study sample, they state that

boys were engaged in physical activity 20 more daily minutes than did the girls. The authors explained that girls may have lower intentions and expectations to exercise, lower perceived behavioral control, lower self-confidence to exercise, less social support and less enjoyment of PA and sports participation than boys [28].

Weaker performance of Roma children in the *manual dexterity* was expected. They live mostly in a powerty of deprived surroundings of small crowded houses with lack of the furniture and sometimes even without electricity or running water. Families commonly have many children sharing just one toy, while the households missing small house utensils like the scissors, pencils or paper and other play material which dramaticaly reduce opportunities for practice and development of fine motor skills. Relations of fine motor skills and school success are well established in many studies. It is known that, in preschool age, fine motor skills predict later reading and math achievement [29]. We found that *manual dexterity* significantly predicted overall *school success* measured as *grade point average*. We also found that beeing of Roma minority substantially lowered children possibilities for academic achievement. Although overall reasons may be complex and multifactorial, we propose primarily lack of reinforcement in learning and practice by parents and siblings as the main reason. It is known that in Roma population older children spend large amount of daily time taking care for their numerous younger siblings. Parents, on the other hand, doesnt find any usefullnes of encouragement of the children neither in motor activities nor in learning and studying in general. The rate of school absenteeism, grade retention and behavioral problems is high. In Roma population in the present study, numerous children were born to teen mother and in their families the official language (native) is not spoken, they experienced pour pre- and postnatal care, and almost all live in poverty. They also did not participate in kindergarten care and education, and therefore missed the early opportunities for organized participation in structured movement and play activities. Fantuzzo et al. [30] indicated that children with early care and education experience scored significantly higher on motor skills than children who did not participate in early childhood programs.

It is known that gender and ethnicity can influence proficiency in *object control skills*, which provide children with the tools to be physically active and which is a major societal priority [31]. This is especially important because the middle childhood is a period of vulnerability during which children with lower actual motor skill proficiency will likely become less physically active because of the lower perceived motor competence [32].

Herbst and Huysamen [33] suggested that environmentally disadvantaged children are superior in activities requiring *gross motor skills*, whereas their peers from more advantaged communities outperform them in fine motor skills. Accordingly, it is reasonable to expect that children from poorer socioeconomic environment should have higher level of gross motor skills due to more time spent in outdoor activities. However, that was not the case in the present study. Moreover, not only was Roma children's performance in *ball skills* (gross-motor) lower, but they also showed significantly lower level of *balance,* which could also be considered a gross motor skill because of the involvement of large muscles of the body in maintaining the body equilibrium. It is questionable whether Roma children spend more time outdoors, but even if they do, it obviously does not automatically guarantee higher level of motor skills. That is in accordance with [34], who observed that children from the lowest socioeconomic families were engaged in less physical activity than children from the highest socioeconomic families, while among girls, those with the lowest socioeconomic status spent the greatest amount of time watching TV ($p = 0.0001$).

Goodway and Branta [35] found that children living in *high-risk environments* are at risk of developmental delays but also school failure. Except for lack of possibilities for motor skills development, in such a milieu, children are exposed to other risk factors that contribute to their overall reduced development, like exposure to drugs, alcohol, or crime. *Equipped playgrounds* are mostly not available to Roma children to the same extent as they are to native children. For optimal perceptual-motor development, stimulating home environment should be accompanied by enjoyable play and exercise facilities and surroundings, which should be accessible, well structured, and should increase children's opportunity to be physically active and to develop motor skills.

6. Conclusions

Our study showed that motor competence is less developed among Roma children than among the native children. Seven percent of Roma children were classified as below normal motor development. Roma children were less successful in gross-motor skills and considerably less successful in fine motor skills than non-Roma children. The latter negatively predicted their school success leaving them behind non-Roma children.

It is reasonable to assume that poverty, parental-social but also environmental factors, significantly influenced children's motor development, as well as their academic achievement and social engagement.

In a broader context of the current immigration processes in Europe, once homogenous communities and neighborhoods may progressively become ethnically and racially diverse. In such complex societies it should be ensured that all children receive optimal social and environmental opportunities, which will increase children's chance for adequate and useful motor experience and thus enhance their development.

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Effect of Service Quality and Rates on Satisfaction and Loyalty of Customer Behavior at Fitness

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Abstract **Purpose:** Regular quality of service and tariffs are generally recommended to be important factors for maintaining customers. The purpose of this study was to determine the effect of service quality on service satisfaction and fitness customer behavior, to determine the effect of tariff on fitness customer behavior loyalty, to determine the effect of satisfaction on customer behavior loyalty at fitness. **Design/methodology/approach:** Type This study was a descriptive research with mixed methods (qualitative and quantitative). The subjects of this research were 85 Customers from two groups: UNY Family and outside the UNY taken by random sampling. Data analysis techniques using correlation and linear regression among indicators-variables, and between variables themselves with Software SPSS.21 and PLS-SEM. **Findings:** The results showed that there was a significant effect of service quality on satisfaction, the effect of service quality on behavior loyalty was largely indirect. The ticket prices have a negative effect on satisfaction and behavioral loyalty. **Research limitations/implications:** Although this study lacks generalizability, thus, service quality and tariffs are strong management instruments to help sports management. Practical implications–Thus, service quality and tariffs are strong management instruments to help sports management to decide the allocation of resources to increase customer satisfaction and loyalty. **Originality/value:** This study is the first to apply to explain career to the current situation in that fitness.

Keywords Service Quality, Tariff, Satisfaction, Loyalty

1. Introduction

The development of the service business world nowadays is so fast and the competition between companies is very great high, so that the companies are required to work more effectively and efficiently (Yildiz & Kara, 2012) [1]. In the field of business, especially fitness has experienced a very rapid increasing, both in terms of quality and quantity in Yogyakarta. In terms of quality, it can be seen that the service quality, the suitability of the rates and facilities provided to customers Santos, J. (2003) [2]. Customers as users of equipment and services in making ticket purchases are much influenced by internal and external factors. These factors have a very large influence in influencing the decision process to buy a ticket or become regular customers at fitness.

In every event the competition is faced by most companies in various industries seems to be getting tighter, the struggle for getting the interesting places will affect their needs in the market Avourdiadou, S. & Theodorakis, N.D. (2014) [3]. The company will get a place in the hearts of customers if everything offered is in accordance with what they want. Therefore a serious understanding of user behavior Kim, P. & Han, J. (2013) [4]. A company in its activities becomes a mandatory thing to manage services properly, so in principle it requires professional management in marketing, operations and human resources, integration of these elements becomes the key of success of service companies in other to improve business performance.

Rapid development in all fields has brought changes in people's lives. Nowadays the community is getting smarter and more critical, both in thinking and carrying out an action R., Mahamad, O. & Ramayah, T. (2010) [5]. This is a challenge and opportunity for organizations / institutions engaged in services. One of the institutions engaged in services is fitness, Yogyakarta State University on the side of Fitness. UNY Fitness has been created in 2008, besides it, there are already five (5) other fitness, which mean that there is already a competition between fitness clubs around UNY. From 2008 there was no research that matched the actual situation in UNY's fitness. UNY fitness staff is not yet informed whether the quality of services is very beneficial to customers.

The purpose of this study was (1) to determine the effect of Service Quality and Rates on Satisfaction and Loyalty of Customer Behavior at Fitness, (2) to determine the effect of tariff on fitness customer behavior loyalty, (3) to determine

the effect of satisfaction on customer behavior loyalty at fitness.

This research was very important because the results showed the strong and weak points belong to UNY fitness club, so it will be an opportunity to improve it. Finally the information from this study was to help UNY fitness clubs to prepare for the competition and maintain the customers, not only fitness club but for all business owners such as development guidelines.

2. Literature Review

2.1. Service Quality

Quality of service is centered on efforts to meet customer needs and desires and the accuracy of delivery to offset customer expectations. Service quality is the expected level of excellence and control over the level of excellence to meet customer desires Christian Grönroos, (2001) [6]. Quality is the starting point in seizing market share so that the level of satisfaction not only needs to be maintained but also must be increased to face increasingly fierce competition Nguyen, N., & Leblanc, G. (2001) [7]. Therefore the company is required to be able to mobilize, organize and coordinate the activities of various groups of professional, semi-professional and non-professional personnel, so that they can achieve the planned goals.

Customer satisfaction will be the basis for developing various models of buyer behavior Olorunniwo, F., Hsu, M. K., & Udo, G. J. (2006) [8]. In addition, customer satisfaction is a guideline to direct the entire organization towards meeting customer needs so that it becomes a source of sustainable competitive advantage. Consumer satisfaction with the services provided by the company will be known when making a measurement and testing of consumers. Service at a satisfactory value if the service can meet the needs and expectations of consumers. Consumer satisfaction measurement is an important element in providing better, more efficient and more effective services. The use of service quality dimensions as a measuring tool that is expected by a company to determine the level of customer satisfaction.

Knowing the results of measuring customer satisfaction companies can prepare a strategy that will be applied in order to create consumer loyalty. In fact, customer satisfaction is often overlooked or not properly considered by every individual in the organization. From the perspective of the customer / consumer there are often so many complaints regarding product quality, prices that are too high Soteriou, A. C., & Stavrinides, Y. (2000) [9]. Nowadays and in the future in line with the developments that occur, the level of public education is increasing; the way of thinking becomes more modern followed by an awareness of the importance of service quality. There are four determinants of service quality, which include direct evidence of equipment, staff, price and program. The aforementioned variables greatly influence customer satisfaction with the quality of services provided by the company and have an impact in trying to create customer loyalty. Variation in shape, quality and type depends on who, when and where the service is produced in this case the service provider can do three stages in quality control: 1) Investing, selecting and training good personnel. 2) Standardizing the service implementation process. 3) Monitor user satisfaction through a system of suggestions and complaints, consumer surveys so that poor services can be detected and corrected.

2.2. Tariff

Rates or prices are the first aspects that need to be considered by the seller in an effort to market their products, and in terms of buyer prices are one of the aspects that determine whether to buy or not. To determine the price level of an item a market test is usually carried out Nusair, K., Yoon, H. J., Naipaul, S., & Parsa, H. G. (2010) [10], meaning that the price of the item to be determined can be accepted or not by the buyer. If it cannot be accepted, the price of the item can be immediately changed. Price is the amount of money (plus several products if possible) needed to get a number of combinations of products and services.

Determining of the price level is usually done by making a number of changes to test the market, does it accept or reject? If the market accepts the offer, then the price is appropriate. But if they refuse it, then the price needs to be changed as soon as possible. So there is a possibility of a wrong decision about the price decision taken by management. In decision making the determination of the tariff needs to be reviewed whether the goal is for the seller to set the price or price of the product. These objectives include Zineldin, M. (2006) [11]: 1) Increase sales 2) Maintain and improve market share 3) Price stabilization 4) Reach the investment return target 5) Reach maximum profit and so on.

2.3. Customer Satisfaction

Satisfaction has a very relative understanding, because the satisfaction of consumers is very dependent on each individual who feels it. Consumer satisfaction is basically closely related to meeting the needs of consumers themselves.Satisfaction is defined as post-consumption evaluation that an alternative chosen at least meets expectations. In short, these alternatives at least work as well as expected (Payne & Frow, 2013) [12]. Dissatisfaction, of course, is the result of expectations that are confirmed negatively. In general, satisfaction is the feeling of being happy or disappointed someone who comes from a comparison between the impression on the performance (or results) of a product and its expectations Seth, N., & Deshmukh, S. G. (2005) [13].

Consumers are people who receive the work of a person or organization, so only those who can determine the quality of what and only those who can convey what and how their needs. There are several important elements in quality that are set by consumers. Yeung, M. C. H., Ging, L., & Ennew, C. T. (2002) [14]:

a) Consumers must be the top priority for organizations because the survival of the organization depends on the consumer.
b) Reliable consumers are the most important consumers. Reliable consumers are consumers who buy multiple times (repeat purchases) from the same organization.
c) Consumers who are satisfied with the quality of products or services purchased from an organization become important consumers. Therefore, customer satisfaction is very important.
d) Consumer satisfaction is guaranteed by producing high quality products. Satisfaction has implications for continuous improvement so that the quality must be renewed as long as consumers remain satisfied and loyal.

Consumers do have to be satisfied, because if they are not satisfied they will leave the company and become competitor consumers, this will cause a decrease in sales and in turn will cause a decrease in sales and will reduce profits and even losses Szmigin, I. & Carrigan, M. (2001) [15].

2.4. Loyalty Behavior

Consumer loyalty can be used as a basis or benchmark in taking policies to add or reduce the value of products for consumers. Tiessen-Raaphorst, A. & Broek, A. van den (2016). Where the company will obtain information from consumers that is about the activities of interpreting, processing, and storing information about products and brands. Therefore customer loyalty from consumers' confidence in making purchasing decisions. Consumer loyalty can show how much a consumer's support for the product or service offered by the company Pedragosa, V. & Correia, A. (2009) [16].

On the other hand, consumer loyalty can prove the level of consumer confidence in the products or services offered by the company Parasuraman, A., Berry, L. L., & Zeithaml, V. A. (1993) [17].

2.5. Method and Material

This is the descriptive research with mixed method qualitative and quantitative approaches. The population in this study was UNY fitness customers, amounting of 85. The study sample was determined by random sampling . Data collection techniques used questionnaires. Data analysis techniques using PLS - SEM and SPSS. The research hope was to show the actual situation in UNY fitness through the below Indicators and variables :

(1) Equipment, (2) Staff, (3) Service, (4) Program the later are indicators for the Service Quality variable, however the Attitude was an indicator of Variable customer satisfaction at Fitness, in add more Participant and Behavior were the Loyalty indicators. Secondly the all variable (dependent and Independent) were the following below:

a. Service quality variable (X1): dependent variable
b. Tariff variable (X2): dependent variable
c. Variable customer satisfaction at Fitness (Y1): independent variable
d. Loyalty of customer behavior at Fitness (Y2): independent variable

The research model and hypothesis in this study can be described and explained:

A. Research Hypothesis

1. There is correlation between indicators and Variable.
2. There is correlation between dependent variable and independent variable.
3. There is linear regression between dependent variable and independent variable.

B. The Research Structural Equation Modeling

The diagram below will help us to find the correlation that will exist between the indicators and the variables, and secondly the correlation that will exist between the variables themselves as the research hypotheses demonstrated above in A.

This research structural equation modelling has four variables and eight indicators, 4 indicators (equipment, service, staff, and program) for the service quality variable; 2 indicators (behaviour and participant) for loyalty independent variable; one indicator attitude for satisfaction independent variable; one indicator price for tariff dependent variable all will be showed on the diagram below.

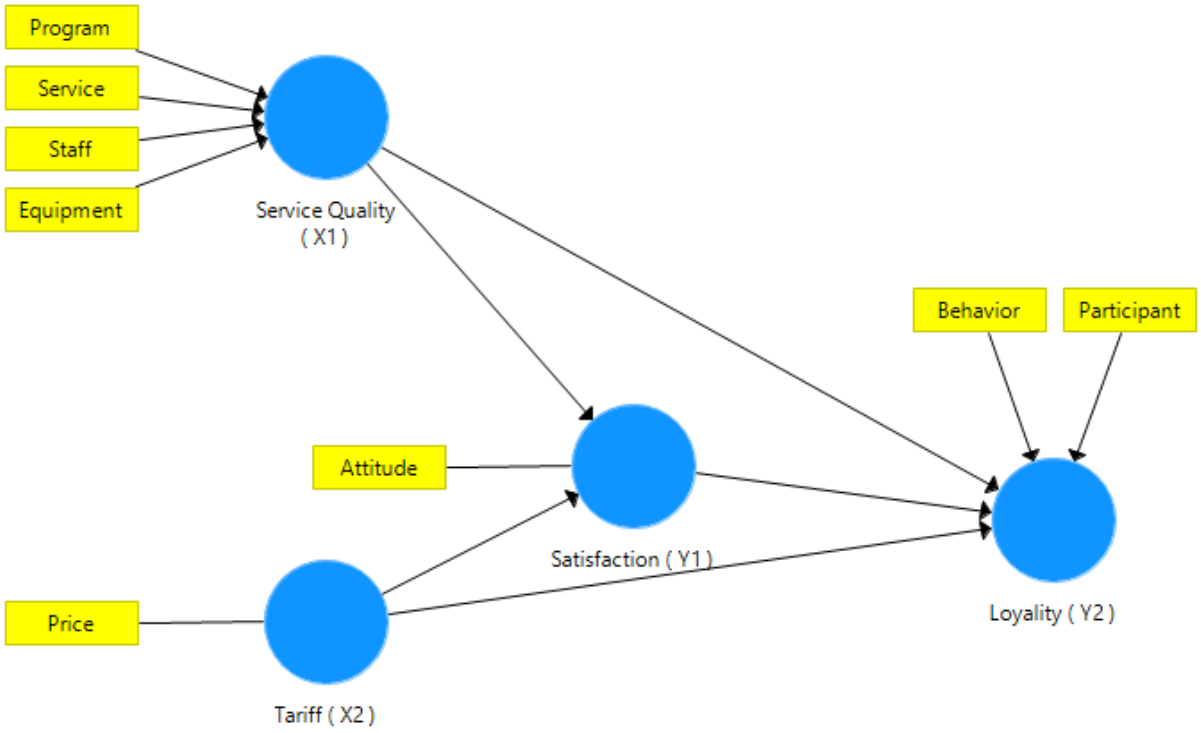

Diagram 1. The Research Structural Equation Modeling

Table 1. Internal consistency reliability (CR) and convergent validity (AVE).

Construct Reliability and Validity

Matrix	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted
	Cronbach's Al...	rho_A	Composite Rel...	Average Varian...
Loyality	0.839	0.844	0.841	0.726
Satisfaction	1.000	1.000	1.000	1.000
Service Quality	0.478	0.622	0.480	0.268
Tariff	1.000	1.000	1.000	1.000

3. Result Research

The result from this research has been presented and explanned such us:

In the Table 1: latent Variables Cronbach's Alpha rho-A Composite Reliability CR Average Variance Extracted(AVE). Reliability of internal consistency is assessed by evaluating of the combination reliability of all constructions. In our study, all composite reliability values were well above the 0.70, expect to the service quality dependent variable in the first case, threshold, indicating that the combined reliability of each reflective latent variable was acceptable and confirmed construct reliability (Hair et al., 2014; Lowry & Gaskin, 2014). See Table 1

Construct validity is the extent to which items measure (Hair, Anderson, Tatham, & Black, 1995, p. 641). To test construct validity, we tested convergent validity and discriminant validity. Convergent validity is the extent to which an AVE measure reflects the average communality for each latent factor (Garson, 2012) , and must be 0.50 or higher (Hair et al., 2014). In our study, all AVE values above 0.50, show dimensions and show that convergent validity of each latent factor is acceptable, except latent variable service quality. (Table 1)

To assess collinearity, we consider the variance inflation factor (VIF). As can be concluded from Table 2, the VIF values in our study are well below the threshold value of 0.50, indicating that collinearity is not a problem (Hair et al., 2011)

Table 2. Collinearity Assessment (VIF).

Collinearity Statistics (VIF)

Outer VIF Values | Inner VIF Values

	VIF
Attitude	1.000
Behavior	2.091
Participant	2.091
Price	1.000
Program	1.058
Service	1.099
Staff	2.103
Equipment	2.088

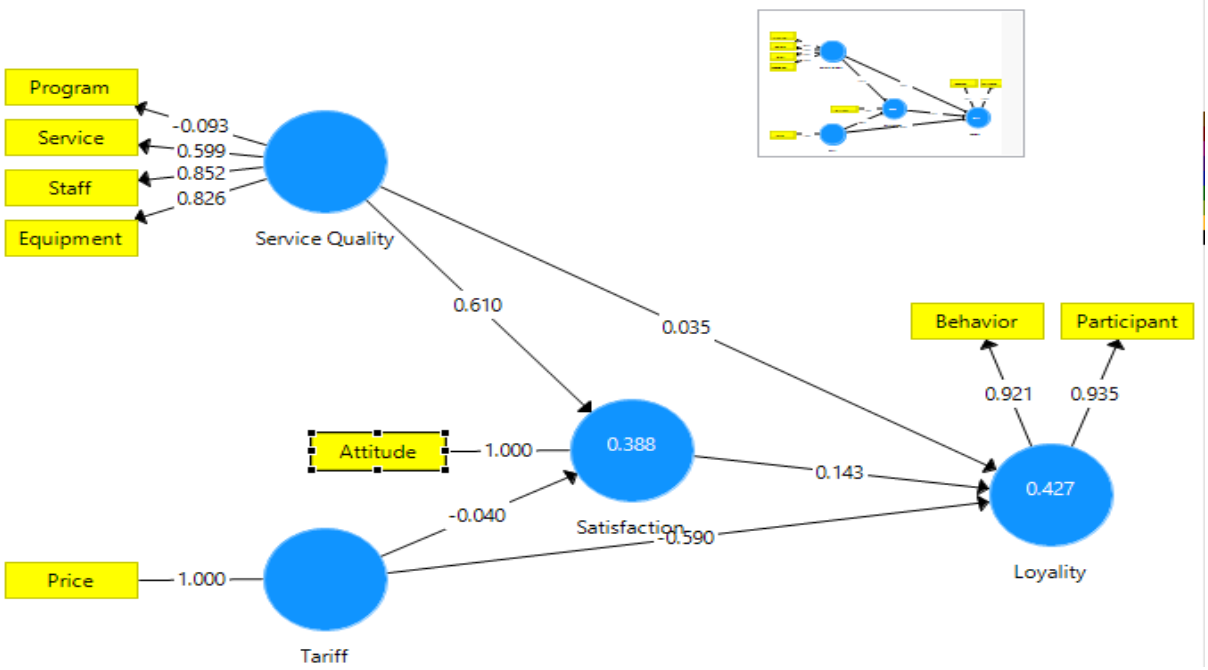

Diagram 2. The Research Structural Equation Modeling Result

This picture presents the relationship or correlation between indicators and variables, is there any influence from the indicator on the variable or the influence between variables themselves. From the results of the research obtained and based on the type of correlation like: a strong positive correlation from 1 to (0.5) and a strong negative correlation from -1 to (-0.5) while the weak correlation is positive from between 0.5 to 0.00 and a weak negative correlation from -0.5 to 0.00, this image showed the strong correlation between service, staff and equipment to the service quality. So the service quality is positively influenced by equipment (0.826), staff (0.852) and service (0.599), nevertheless one of the service quality indicators: program, the result showed that there was a weak relationship or the luck of strong relationship between program and service quality showed the necessity of improving the schedule of the fitness in other to maintain the service quality.

The strong positive correlation between service quality and satisfaction (0,610) showed the good management of the indicators of the service quality which indirectly positively influenced the satisfaction of the customers in the fitness. The behaviour loyalty was not directly influenced by the service quality with the weak negative

correlation of -0,093; this one has been explained by the great amount of customers who were not satisfied by the program of the fitness.

The SEM showed a weak negative correlation between the tariff and the satisfaction of the customers (-0.040), and also showed a strong negative correlation between tariff and behaviour loyalty (-0.590). Whether strong negative or weak negative correlation it gave automatically idea that if the values of X or independent variable decrease the consequences the values of Y or dependent variable increase. What that's meaning in this case: The explanation is very simple, if the fitness decreases the ticket price, the customers will be satisfied to continue to visit that place..

There is linear regression between dependent variable and independent variable.

Linear regression is a common Statistical Data Analysis technique. In simple linear regression a single independent variable is used to predict the value of a dependent variable. Linear regression attempts to model the relationship between two variables by fitting a linear equation to observed data. A linear regression line has an equation of the form Y = a + bX, where X is the explanatory variable and Y is the dependent variable. In this research the explanatory variable is the Tariff (X), and the Satisfaction (Y1), Loyalty (Y2) dependent variables. With the software SPSS this research hypothesis have been verified:

H0: There are no relationships among variables: Tariff, Satisfaction, and Loyalty.

Ha: There are significant relationships between variables: Tariff, Satisfaction, and Loyalty.

According to the result below **Diagram 3** and **Table 3** showed a significant relationship between tariff and Loyalty with confidence interval of 5%. The following **Table 4** showed the strong positive correlation among the indicators- variables, and variable among themselves as the same it has been explained by SEM. The linear regression showed that if the price decreased certainly the customers will increase, finally for the paired samples correlations: pair 1, 2, 4, 5, 7, 8, and 9, H0 is reject and received Ha: the is a relationship between indicators- variable , and variable- variable except pair 3 and 6 characterized by the absent of relationship.

In general the study was centered on the search of the correlation which would be between indicators - variable, and the variables between themselves. The regression search allowed to see if the independent variables predict on the values of the dependent variables.

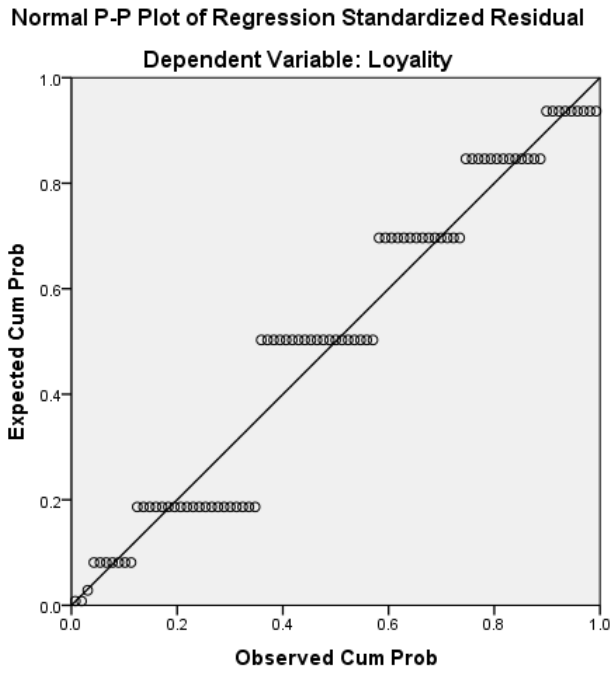

Diagram 3. Regression Standardized Residual Loyalty-Tariff

Table 3. Analyse Regression Tariff-Loyalty

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.213	1	5.213	30.470	.000[b]
	Residual	14.199	83	.171		
	Total	19.412	84			

a. Dependent Variable: Loyality

b. Predictors: (Constant), Tarif ini Rp

Table 4. Significance testing results of the structural model path coefficients Correlation.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Equipment & Service quality	85	.180	.009
Pair 2	Staff & Service quality	85	.218	.045
Pair 3	Program & Service quality	85	.183	.093
Pair 4	Tarif ini Rp & Satisfaction	85	-.225	.039
Pair 5	Service quality & Satisfaction	85	.518	.000
Pair 6	Service quality & Loyality	85	.151	.168
Pair 7	Satisfaction & Loyality	85	.406	.000
Pair 8	Participant & Loyality	85	.722	.000
Pair 9	Tarif ini Rp & Loyality	85	-.518	.000

4. Discussion

The most important contribution of a research is to show how the auctions can be effectively operated by facilitating the service quality of auctioneer and seller. Yen, C., & Lu, H. (2008) [19]. The proposed research model examines loyalty intention regarding trough satisfaction, service quality and tariff in the fitness. With the above statement, it can be seen the strong positive relationship among indicators and variables. Service quality directly influences customers' trust, service quality directly empirical customer loyalty, and customer trust measure the influence of service quality on customer loyalty Mahmud (2017) [20] As a result the Influence of Customer Satisfaction as an Intervening Variable between Service Quality and Customer Loyalty it has directly affected by the good management of service quality through its indicators. The results of original sample, Structural Equation Modeling (SEM) and linear regression Statistics calculations prove that there is a strong positive correlation and significant influence between service quality on customer satisfaction, and customer satisfaction on customer loyalty was not significant because of the tariff in the fitness was not moderated. However, behavioral loyalty is strongly negative influenced by the discomfort fitness rates or tariff. In today's turbulent economic environment service quality is an invaluable asset that business should manage in order to survive and gain a competitive advantage Kranias, A., & Bourlessa, M. (2013) [21]. All hypotheses were verified and confirmed.

5. Conclusions

Based on the results of the research and discussion that have been put forward, conclusions can be drawn: a strong relationship among service quality on customer satisfaction at the Fitness Club has been demonstrated as the basic of increasing customers, nevertheless the high price negatively influenced the participation of customers in the fitness, the role of satisfaction in shaping users' continuance intention is very great to maintain the customers. Thus, service quality and tariffs become strong management tools that help sports managers to decide how to allocate resources to improve satisfaction, customer loyalty. Quality of service directly affects customer satisfaction. It can be said that customers will believe in the fitness UNY, if the fitness UNY increase attention to physical facilities, including update its program, service procedures, such as fitness employees in helping customers during the training, for example for the new comers , inform the customers appropriately, providing the service to the visitor sincerely (wholeheartedly), and to reduce the tariff. In addition, employees are able to create close family relationships and while communicating using empathy, where employees hear more when customers complain, so employees can dig deeper into customer wishes and complaints, which employees can then offer the solution.

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Recurrent Hamstring Injuries in Elite Athletes – A Paradigm Shift to Mechanical Dysfunction of the Sacroiliac Joint as One Causation

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Abstract Recurrent hamstring injuries is a significant and troubling issue in the elite athletic community. Reinjury may occur in up to 34% of patients in the kicking and running sports. We hypothesised that a proportion of these patients may have mechanical dysfunction of the sacroiliac joint as a causative mechanism. We recruited 23 elite athletes with recurrent hamstring injuries and lateralising lower back pain into the study after careful screening. Diagnosis was confirmed by scintigraphic SPECT/ CT imaging. Patients who failed directed physiotherapy were offered injection of the sacroiliac joint with platelet rich plasma (PRP). All 23 athletes (Av age 35 years, 19 M, 4F) had MRI evidence of hamstring tears (Av 4.2 tears) and met criteria for a diagnosis of sacroiliac joint dysfunction with mean clinical scores of 6.8 (Range: 7-9). Four patients returned to sport after physiotherapy and 19 underwent peri-articular PRP injection under ultrasound guidance. The baseline VAS was 80 (mean) and after treatment 9, indicating a significant response to treatment ($p=0.002$). All patients with SIJ dysfunction and recurrent hamstring tears responded to treatment. A plausible explanation for the relationship is the alteration in muscle sequencing around the pelvis following SIJ dysfunction.

Keywords Sacroiliac, Incompetence, Hamstring, Ultrasound, SPECT/ CT, PRP

1. Introduction

Hamstring injuries are common in professional athletes, particularly in the rugby codes or any sport that involves kicking and running (1,2). Unfortunately, re-injury is extremely common following hamstring injury, rates as high as 34% being reported by a number of authors (3,4). Furthermore, re-injury is associated with more severe symptoms and a prolonged recovery time. We have noted the prevalence of hamstring enthesopathy in the vast majority of patients with mechanical dysfunction of the sacroiliac joint (sacroiliac joint (SIJ) incompetence) (5). While hamstring enthesopathy was prevalent in the general group of patients with SIJ dysfunction, the majority of these patients were relatively symptom-free at these sites, the clinical condition being dominated by pain arising from the affected joint. Clinical examination would often demonstrate significant alterations in muscle control around the pelvis and hips. These findings were apparent in 60% of 1200 cases with mechanical dysfunction of the sacroiliac joint (6). This was in sharp contrast to the elite athletes with recurrent hamstring injury.

Muscle enthesopathy was more clinically relevant in athletes with high demands on the lower limbs, such as in football and the rugby codes. A pattern of recurrent hamstring injuries began to emerge, often on one side, in patients with vague histories of lower back pain. Recurrent trauma was often present with rare histories of discrete trauma to the buttocks. The importance of the hamstring enthesopathy was relatively under-appreciated in the cohort of patients with established SIJ dysfunction until these elite athletes with recurrent hamstring injury presented for evaluation of possible mechanical dysfunction of the sacroiliac joint.

Examination demonstrated evidence of occult SIJ dysfunction in this group, with a good response to treatment with directed physiotherapy and or prolotherapy (7) / platelet rich plasma injection (8) into the posterior aspect of the joint.

We hypothesised that the hamstring injuries in these elite athletes were due to the altered biomechanics in the pelvis resulting from mechanical dysfunction of the SIJ. A mechanism of the injury was postulated and evidence for

its utility was proposed and supported by the response to specific therapies.

2. Materials and Methods

2.1. Patients

Elite athletes with a history of recurrent hamstring injuries and lateralsing lower back pain were referred from multiple centres by orthopedic surgeons, sports physicians and physiotherapists to two sports physicians (JS and MC) with a specialized research interest in lower back pain. Data was collected over a period of 3.5 years. Patients were excluded if there was a history of surgery to the SIJs, prolotherapy or PRP to the joint. All other patients were included. Diagnosis of the hamstring injury was based on history, physical examination and MRI. All patients had undergone extensive rehabilitation of the injury with strengthening exercises plus surgical repair in 4 patients. Recurrent injuries however continued in the cohort of patients. All patients were clinically assessed for mechanical sacroiliac joint dysfunction according to the European guidelines (9) and a clinical score derived from the physical examination. A visual analog pain score (VAS) was obtained at baseline and after frequent follow-up visits after instigation of specific treatment for the SIJ dysfunction. Initial diagnoses of the SIJ dysfunction were confirmed by single photon emission computed tomography of the standard bone scan and fused with x-ray computed tomography (SPECT/ CT) as described elsewhere (5). All patients also underwent baseline and follow-up MRI studies of the hamstring tendons at the conclusion of therapy.

The study was approved by the Institutional Ethics Committee of the University of Notre Dame, Sydney Campus.

2.2. Treatment

Initial treatment of the SIJ dysfunction was by directed physiotherapy with review at 6 weeks as described elsewhere (10,11). Briefly, physiotherapy treatment focused on inhibition of muscle recruitment and deficiencies in muscle functional strength. Ultrasound feedback was utilised initially for activation of targeted deep lumbo, pelvic, hip and gluteal muscles, followed by progressed functional strength exercises of key muscle groups to re-establish force closure of the pelvic ring. Therapy was also applied to the primary site of injury, being the dorsal interosseous ligament (DIOL) of the sacroiliac joint. This was achieved with prolotherapy to the ligament with significant improvements in function (7). More recent work with platelet-enriched plasma (PRP) injections into the DIOL also led to significant improvements in symptoms and pain control (8). The major advantage of PRP therapy over dextrose injection was patients required fewer injections (mean of 1.6 versus 3.0), and were able to avoid exposure to radiation as CT guided injections were replaced with ultrasound guided injections for PRP therapy.

2.3. Statistics

Statistical analysis was performed using the ANOVA model and paired t test analysis from the Statistical Package for the Social Sciences (SPSS) Version 24 (IBM, New York, USA).

3. Results

3.1. Patients

The study cohort comprised 23 elite athletes (Rugby Union 8, Rugby league 9, Oz Tag 2, Long-distance runners 2, Triathletes 2). There were 19 males and 4 females with an average age of 35 years (Range: 22-54 years). Patients reported a mean of 4.2 tears of the hamstring muscle/ tendon (Range 1-10 tears). The average time to diagnosis of the sacroiliac joint dysfunction was 36 months (Range: 3-84 months).

Patients were referred to two sports medicine physicians (JS and MC) for an opinion regarding possible mechanical dysfunction of the SIJ. All 23 patients were found to have SIJ dysfunction with an average clinical score of 6.8 (Range 7-9) (9). Of these cases, 18 were on the right side, 5 on the left with 3 being bilateral. Clinical scores for the diagnosis of sacroiliac joint dysfunction had a mean of 6.8 (Range 6.0-8.0).

3.2. Imaging

Patients underwent MRI of the hamstring complex in all instances. The majority also underwent post-treatment MRI before return to sport. Patients reported a mean of 4.2 tears of the hamstring muscle/ tendon (Range 1->10 tears). Three patients reported bilateral hamstring tears, 15 were left sided and 5 right sided.

The sacroiliac joint dysfunction was assessed by fused single photon emission computed tomography (SPECT) of the bone scan with x-ray computed tomography (CT). Imaging findings indicated the right SIJ as the primary site of dysfunction in 15, left in 6 and both joints in 2. The dominant hamstring enthesopathy was left-sided in 18 and on the right in 5.

3.3. Treatment Response

Of 23 patients treated with physiotherapy alone, 4 had a good enough response to return to elite sport. The remainder had partial or no response with persistent pain at

the site of the hamstring injury. These patients were switched to PRP injection under ultrasound guidance. The sacroiliac joint that was the dominant side of dysfunction based on the SPECT/ CT findings and clinical assessment was injected with PRP twice. The baseline VAS score was a mean of 80.0 (Range 65.0-90.0). Following treatment, the mean score was 9.0 (Range 0-50.0). The paired t test confirmed a significant improvement in the VAS scores following treatment (p=0.002).

4. Discussion

This study provides a linkage between mechanical dysfunction of the sacroiliac joint and alterations in muscle function around the pelvis which has the potential to lead to recurrent injuries of the hamstring muscles in elite athletes. It extends a series of observations that included hamstring tendon enthesopathy in patients with SIJ dysfunction (6) to specific physical injury to the tendon and muscle itself under high-level athletic activity. The improvements in the VAS scores were highly significant and more importantly, most athletes were able to return to their chosen sport at an elite level. However, unlike the general non-athletic population, 80% of whom improve with directed physiotherapy (7), only 4 elite athletes responded to conservative treatment and the majority required intervention with PRP injection. It indicates more severe injury to the SIJ and hence the chain reaction of abnormal muscle sequencing and proclivity to injury.

Mechanical dysfunction of the sacroiliac joint was described as long ago as 1905 (12). The concept was lost from medical consciousness with publication of the citation classic on the importance of the intervertebral disc as a cause of back pain in 1934 (13). The importance of the condition as a cause of lateralising low back pain with a pain distribution identical to intervertebral disc prolapse slowly re-entered medical consciousness in the 1990s and 2000s. This was precipitated by initial work published by Solonen in 1957 (14), with subsequent recognition of the joint as a source of low back pain in pregnancy (15). Multiple authors published on the condition (16-19) with evidence-based validation of clusters of physical tests culminating in publication of the European guidelines for a firm clinical diagnosis in 2008 (9).

Knowledge of the anatomy is crucial in understanding the relationship between mechanical dysfunction of the sacroiliac joint and hamstring tears. The primary function of the pelvis during weight-bearing is to transfer the loads generated by body weight and gravity from the spine to the lower limbs (20). The SIJ joints are relatively stable, yet flexible enough to absorb the changing forces across the joint. Ligamentous structures that surround each SIJ and the pubic symphysis create both tensile and compressive forces across the joint that limit the range of intrapelvic motion (21, 22). The flexibility is a result of the inter-relationship between the muscles, their internal fascial and complex external fascial elements that lead to a web of synchronised support for the pelvis (22). While the sacroiliac joint is L-shaped it has a longer horizontal then vertical arm. A tubercle on the iliac side locks into a concavity on the auricular portion of the sacrum, dorsal to the joint. This is the axis of movement of the joint (S2), allowing nutation (forward rotation) and counter-nutation (backward rotation). Irregularities in the joint surfaces and the wedge-like shape help lock the sacrum between the two iliac bones in a keystone configuration (22).

Sequential contraction of muscles, muscle groups and the fascial attachments (23) allow the co-ordinated “force closure” of the pelvic ring, helping reinforce the “form closure” of the two iliac bones around the sacrum (11). It is this combination that allows both stability and flexibility in order to handle the forces generated by ambulation and other movements (24). The contribution of muscle force to stabilisation of intrapelvic motion is based upon optimal patterning and activation of local and global muscles together with the synergistic tensioning of ligamentous structures that principally increase the stiffness of the sacroiliac joint prior to weight transfer (11,25,26).

There are multiple ligaments that support the SIJ (22). Core ligaments are numerous and include the ventral, dorsal and interosseous ligaments and the associated short and long dorsal sacroiliac ligaments. The dorsal interosseous ligament (DIOL) is the strongest supporting ligament of the joint and fills in the space that is dorsal and cephalad to the synovial portion of the joint (mainly at the S1 and S2 levels). This allows the sacrum to sit in a stable configuration between the iliac bones and allows anterior motion into the pelvic ring (nutation - mainly due to contraction of the erector spinae and gluteus maximus) with sequential abdominopelvic muscle contraction closing the pelvic ring. Sturesson et al (20) have shown that nutation of the sacrum occurs bilaterally when the spine is loaded vertically with counter-nutation of the sacrum or anterior rotation of the iliac bone being a relatively less stable position for the SIJ, which subsequently causes loading onto the long dorsal sacroiliac ligament (27). The stability of the sacroiliac joint is enhanced by the wedge angle of the joint and the coefficient of friction of the roughened surfaces of the sacral and iliac articular surfaces (28). This effectively creates a self-bracing effect of the joint that relieves some of the stress on the ligaments that support it. One of the most important structures that influences the self-bracing mechanism is the sacrotuberous ligament and by implication, the muscles that are connected to or converge on it (29,30). While the cranial portion of the sacrum can rotate anteriorly around the S2 axis, this motion is restricted by the sacrospinous and sacrotuberous ligaments (Figure 1) (22). Counter-nutation (posterior movement of the sacrum) is restricted by the long dorsal ligament (22). Any injury that leads to abnormal movement of the sacroiliac joint can alter the

information sent from mechanoreceptors receptors at the articular surface of the joint to the brain (31) and this may explain the pattern of inhibition of the transversus abdominis, multifidus and ipsilateral gluteus maximus which is commonly reported with SIJ dysfunction (25). When the SIJ is injured, there is significant alteration in intra-pelvic motion and the sacroiliac joint glide. The chain reaction is a linkage to altered lumbopelvic muscle activation (25,27,32,33). If the SIJ is no longer able to maintain its closed pack position with weight-bearing, it essentially unlocks with anterior rotation of the iliac bone and sacral counter-nutation (25,34). This transmits increased strain onto the long dorsal sacroiliac ligament, creating pain in the ipsilateral buttock that is often described as worse when weight-bearing. Normal recruitment of abdominopelvic and hip muscle contraction that aid dynamic closure of the pelvic ring is disrupted by chronic pain. Local lumbo-pelvic muscle activation may be inhibited while global muscle activation becomes more tonic. Maladaptive strategies are applied with muscle splinting and bracing in an attempt to increase pelvic force closure (35). There is some evidence that hamstring spasm may accompany the dysfunction in a reflex attempt to stiffen the joint (force closure) (36).

Under the circumstances of sacroiliac joint dysfunction, there will be increased tension on the ipsilateral long dorsal ligament to stop counter-nutation. There will also be relative tension on the sacrotuberous/ sacrospinous ligament complex on the contralateral side to prevent relative over-nutation of the other side of the sacrum. Changes on the contralateral side resulting from increased tension in the sacrotuberous ligament will be transmitted to the tendon of the long head of the biceps femoris muscle which is fused with the sacrotuberous ligament in approximately 50% of cases (29). Van Wingerden et al (39) have shown a dynamic relationship between the two structures depending on whether in the flexed or erect position, leading to changes in torque that influence sacroiliac joint stability. The thrust of this work was to explore the effect of hamstring muscle contraction on the sacrotuberous ligament (Figure 1 & 2). We would postulate that increased tension in the sacrotuberous ligament most likely leads to increased tension in the hamstring tendon/ muscle that will predispose it to injury with rapid increases in dynamic tension as occurs in many elite running and kicking sports (Figure 3, 4 & 5). The majority of the hamstring injuries were on the contralateral side to the sacroiliac joint dysfunction, providing support for this hypothesis. Improvements in pain scores and functional parameters allowing return to sport following treatment provides further support for this contention. What of injuries to the hamstring muscle complex on the ipsilateral side of the sacroiliac joint dysfunction?

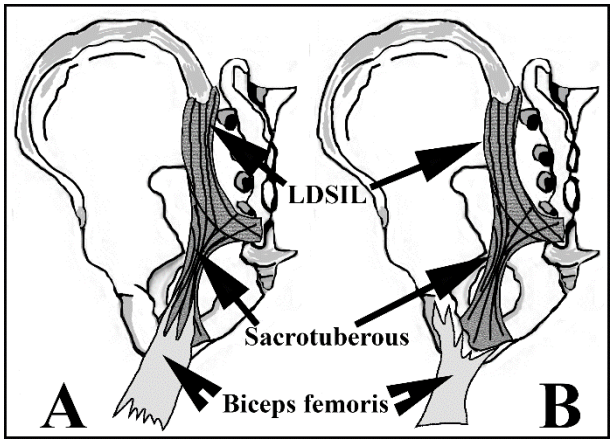

Figure 1. Graphic illustrates the contiguous nature of the sacrotuberous and long dorsal sacroliliac ligaments. Panel A shows that the biceps femoris tendon may be contiguous with the sacrotuberous ligament in a proportion of patients or have a discrete insertion into the ischial tuberosity (Panel B). This concept is demonstrated in the MRI studies in Figure 2.

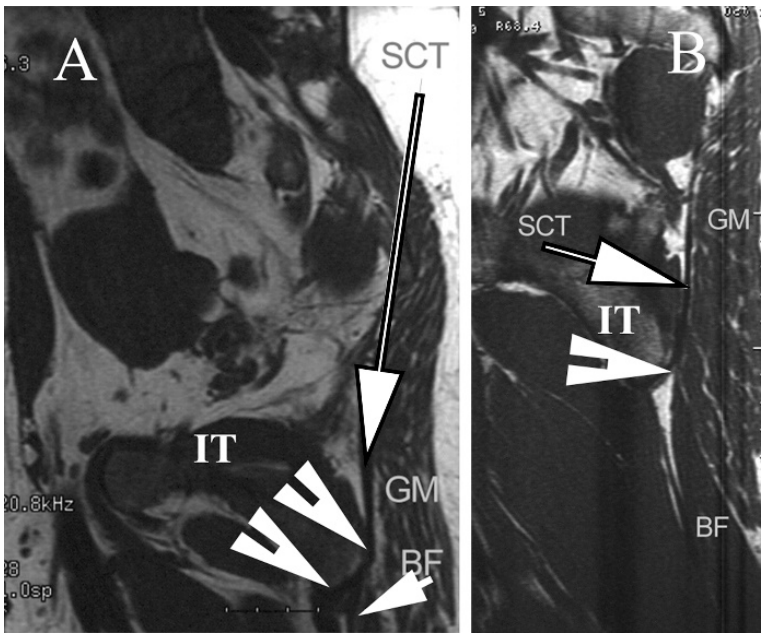

Figure 2. These two MRI studies demonstrate the continuity (arrowheads) of the sacrotuberous ligament and the biceps femoris tendon (arrow) in Panel A together with their connection to the ischial tuberosity (IT). Panel B demonstrates discrete attachments of the sacrotuberous ligament (arrow) and the biceps femoris tendon (arrowhead) on the ischial tuberosity (IT)

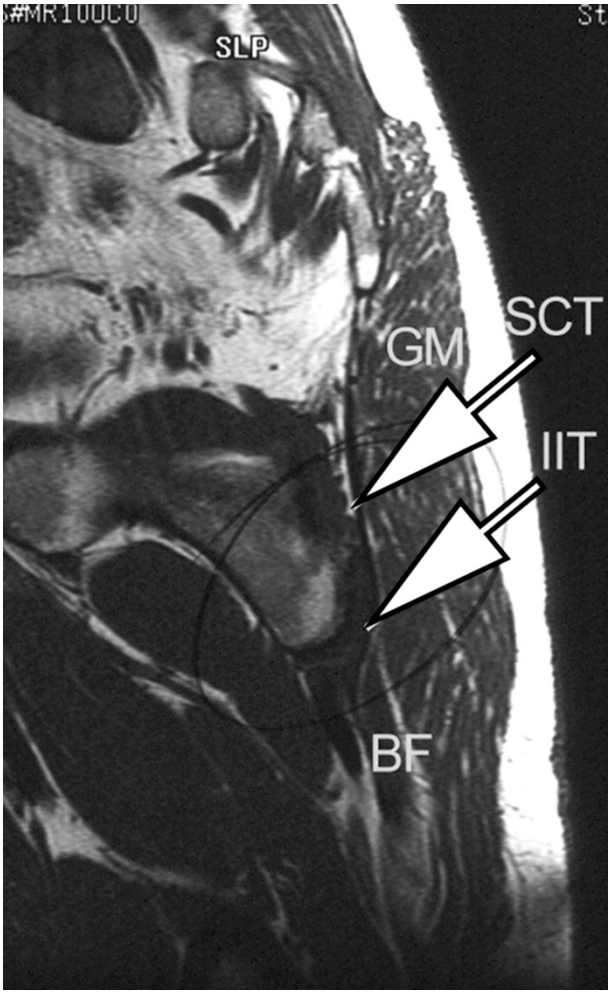

Figure 3. The MRI study demonstrates bone marrow oedema around the site of insertion of the biceps femoris tendon (arrows) into the ischial tuberosity. In this instance, there is continuity of the biceps femoris tendon and the sacrotuberous ligament (upper arrow)

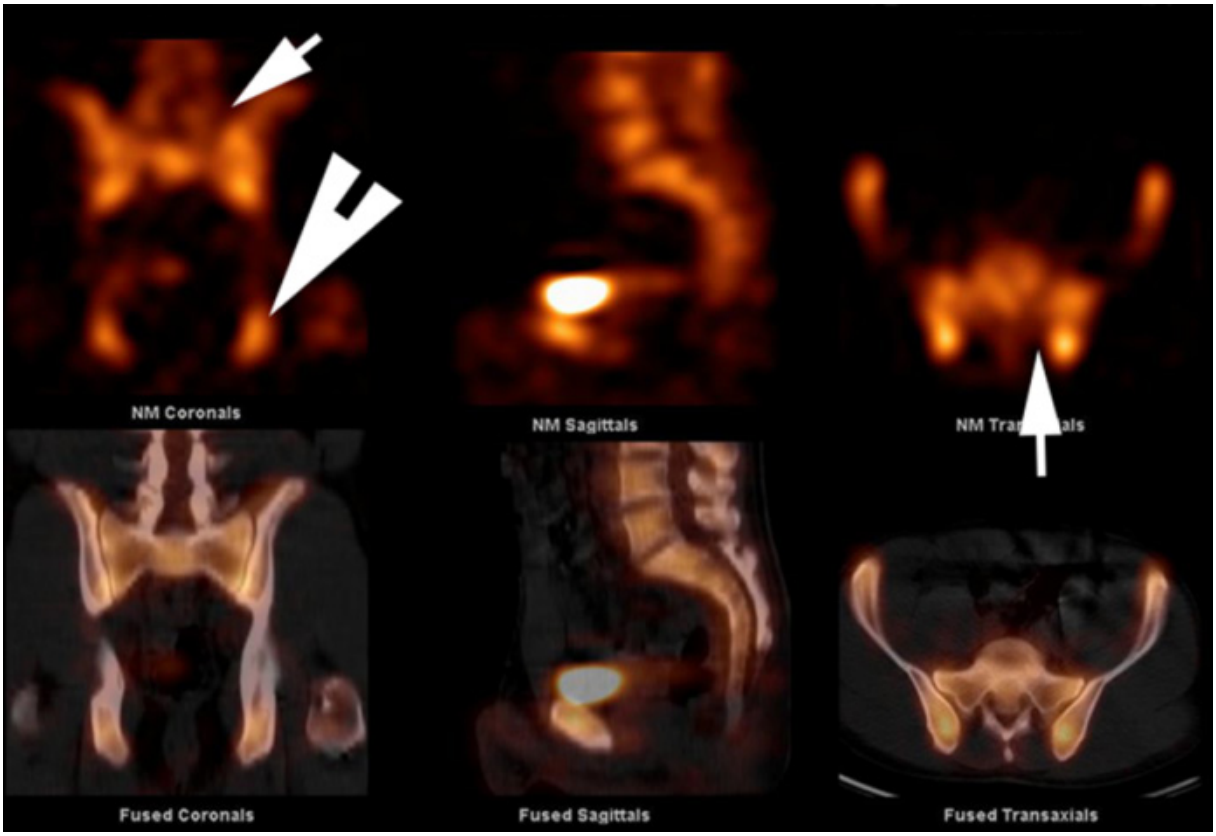

Figure 4. SPECT/CT images of a patient with recurrent hamstring tears on the left side. The arrow in the scintigraphic study shows increased uptake of tracer in the left dorsal interosseous ligament. The arrowhead indicates the site of increased uptake in the ischial tuberosity at the site of insertion of the left hamstring tendon. This patient's MRI is shown in Figure 5

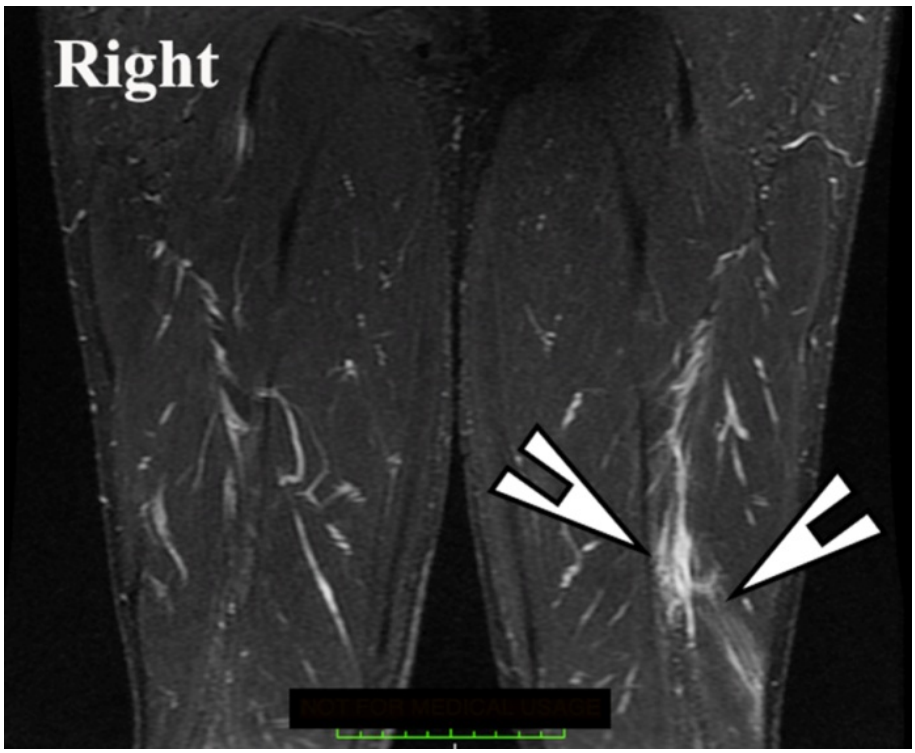

Figure 5. MRI study of the patient was showed in Figure 4. The patient was an elite rugby league player who had sustained recurrent tears of the left hamstring muscle and tendon and also gave a vague history of left buttock pain and recurrent trauma during play. The study demonstrates high signal from multiple tears in the body of the left hamstring muscle (arrowheads). The patient responded well to targeted physiotherapy for the causative left sacroiliac joint incompetence

One could hypothesis that the forces applied to the pelvis are dynamic and ultimately a balancing act. A proportion of patients will have direct fascial connection between the sacrotuberous ligament and tendon of the long head of biceps on both sides (~ 30%) (29). The long dorsal sacroiliac ligament merges with the lateral edge of the sacrotuberous ligament as it descends from the origin on the posterior superior iliac crest (Figure 1) (40,41). This ligament is under increased tension as the pelvis rotates anteriorly (counter-nutation) following injury and dysfunction of the sacroiliac joint. The tension may be transmitted to the ipsilateral sacrotuberous ligament and thereby to the ipsilateral hamstring, predisposing it to recurrent injury. Again, the evidence to support this contention is in the reduction in pain and improvement in function with treatment of the sacroiliac joint dysfunction in the group of patients in this study.

The main purpose of treatment is to maintain a stable closed-pack alignment during weight-bearing activities in order to enable optimal load transfer through the pelvis. This therefore incorporates retraining lumbo-pelvic stability. Treatment must be tailored to fit four generalised subgroups (5,27,42). Treatment should be aimed at SIJ dysfunction due to reduced force closure, excessive force closure, articular injury and extra-articular injury to the ligamentous support network. Treatment is therefore based on a high degree of specificity in assessment and diagnosis in order to use the right therapy, be it manual, exercise, cognitive or combination of all three. Specialised physiotherapy generally deals with the abnormalities in lumbopelvic and hip muscle recruitment, muscular strength deficiencies and tendinopathy, plus functional strength rehabilitation. In some circumstances as with the majority of cases in this study, the injury to the dorsal interosseous ligament of the sacroiliac joint is too extensive and direct therapy to the ligament must be utilised. This has been achieved with prolotherapy to the ligament with significant improvements in function (7). More recently, platelet-enriched plasma (PRP) injections into the DIOL have also led to significant improvements in symptoms and pain control. Saunders et al (8) presented data on 45 patients who had ultrasound-guided injection into the dorsal interosseous ligament of the SIJ. The group was compared to a similar cohort of historical controls treated with prolotherapy by the same group (7). Subjects treated with PRP demonstrated equivalent results at 3 and 12 months with a mean of 1.6 injections versus 3.0 injections in the prolotherapy group. Surgical fusion of the sacroiliac joint is generally considered a last resort, especially in elite athletes and is reliant on centres that undertake the procedure on a relatively frequent basis (43).

When should suspicion of sacroiliac joint dysfunction arise in patients with hamstring injuries? Recurrent injury of the same hamstring is usually the major warning sign. Suspicion may arise from the history of lateralising lower back or buttock pain in the same patient, especially with no imaging evidence of intervertebral disc prolapse. There may be a history of significant trauma to the lower back or buttocks. The clinical examination may yield the diagnosis or suspicion of such an injury, but may be the domain of specialised sports physicians.

Imaging is usually the next sequence. An MRI should be routinely obtained in the case of acute proximal hamstring injuries in order to rule out an avulsion injury from the proximal attachment of the hamstrings to the ischial tuberosity (Figure 6). MRI is useful in determining multiple characteristics of hamstring injuries, including the size and extent of the injury (length and volume), the specific muscle involved (semitendinosus, semimembranosus, and/or biceps femoris - short and long head), the location of the injury (proximal versus distal injuries and muscle-belly injury versus musculotendinous injuries versus intratendinous injuries), and the signal intensity of injuries. MRI will not however yield the diagnosis of sacroiliac joint dysfunction, as has been shown by a number of authors (44,45). Bone scintigraphy with SPECT/ CT has been shown to be a valid diagnostic modality as it also demonstrates enthesopathy and secondary femeroacetabular hip impingement (5,6).

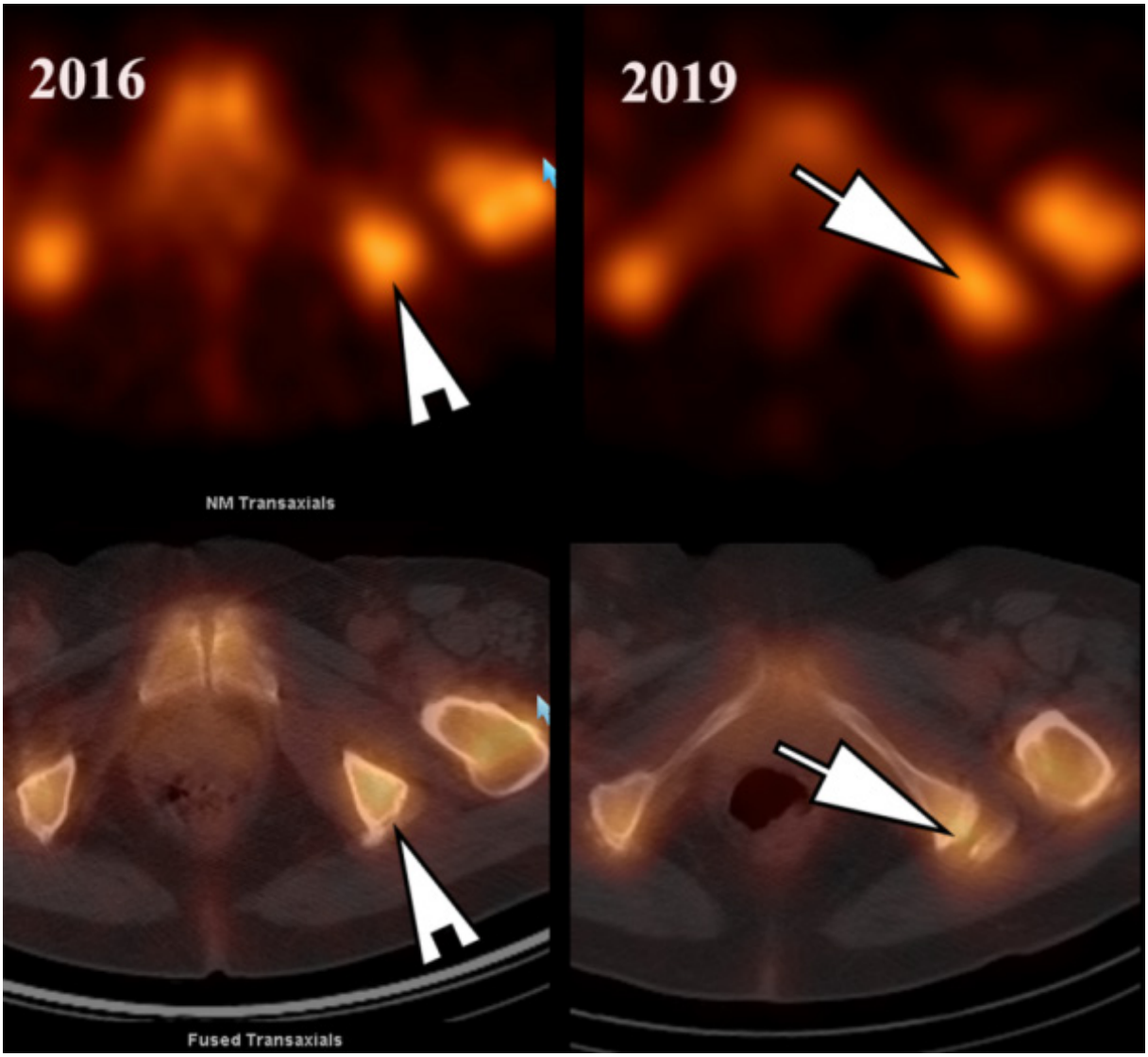

Figure 6. SPECT/CT images of a patient initially diagnosed with left sacroiliac joint incompetence in 2016 for which therapy was not undertaken. Three years later, the patient presented with acutely increasing left buttock pain after falling down stairs. The sequence of images demonstrates enthesopathy at the site of the left hamstring tendon insertion into the ischial tuberosity in 2016 and the subsequent avulsion of the tendon from the tuberosity in 2019

5. Conclusions

Recurrent hamstring injuries are common in a number of elite sporting endeavours. Recurrence on the same side should raise suspicion of possible injury to the sacroiliac joint, especially in contact sports. The diagnosis should be suspected where there is a history of trauma to the lower back or buttocks or there is a history of lateralising lower back pain without imaging evidence of a significant or culprit intervertebral disc prolapse. Treatment of the sacroiliac joint dysfunction is usually successful in approximately 80% of cases with specialised physiotherapy. If physiotherapy is unsuccessful, then alternative therapies such as prolotherapy or PRP injection into the DIOL under imaging guidance can also yield good results and a return to sport.

Conflict of Interest Statement

a. None of the authors have Competing Interests
b. No Funding or grants or equipment were provided for the project from any source.
c. There are no financial benefits to the authors from publication of this manuscript.
d. Details of any previous presentation of the research, manuscript, or abstract in any form. Abstract to be presented at the World Congress of Low back pain in Antwerp in 2019.

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