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Injury and Illness Risk Factors for Elite Athletes in Training Environment

– A comparison between Germany and Taiwan

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Victor C. Wang

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Dean of the faculty: Prof. Dr. Barbara Höhle

First referee: Prof. Dr. Pia-M. Wippert (University of Potsdam)

Second referee: Prof. Dr. med Frank Mayer (University of Potsdam)

Chair of doctorate committee: Prof. Dr. Erin Gerlach (University of Potsdam)

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Potsdam, 25.01.2016

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Victor Chen-feng Wang

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Abstract

Since 1998, elite athletes' sport injuries have been monitored in single sport event, which leads to the development of first comprehensive injury surveillance system in multi-sport Olympic Games in 2008. However, injury and illness occurred in training phases have not been systematically studied due to its multi-facets, potentially interactive risk related factors. The present thesis aim to address issues of feasibility of establishing a validated measure for injury/illness, training environment and psychosocial risk factors by creating the evaluation tool namely risk of injury questionnaire (Risk-IQ) for elite athletes, which based on IOC consensus statement 2009 recommended content of preparticipation evaluation(PPE) and periodic health exam (PHE).

A total of 335 top level athletes and a total of 88 medical care providers from Germany and Taiwan participated in tow "cross-sectional plus longitudinal" Risk-IQ and MCPQ surveys respectively. Four categories of injury/illness related risk factors questions were asked in Risk-IQ for athletes while injury risk and psychological related questions were asked in MCPQ for MCP cohorts. Answers were quantified scales wise/subscales wise before analyzed with other factors/scales. In addition, adapted variables such as sport format were introduced for difference task of analysis.

Validated with 2-wyas translation and test-retest reliabilities, the Risk-IQ was proved to be in good standard which were further confirmed by analyzed results from official surveys in both Germany and Taiwan. The result of Risk-IQ revealed that elite athletes' accumulated total injuries, in general, were multi-factor dependent; influencing factors including but not limited to background experiences, medical history, PHE and PPE medical resources as well as stress from life events. Injuries of different body parts were sport format and location specific. Additionally, medical support of PPE and PHE indicated significant difference between German and Taiwan.

The result of the present thesis confirmed that it is feasible to construct a comprehensive evaluation instrument for heterogeneous elite athletes cohorts' risk factor analysis for injury/illness occurred during their non-competition periods. In average and with many moderators involved, German elite athletes have superior medical care support yet suffered more severe injuries than Taiwanese counterparts. Opinions of injury related psychological issues reflected differently on various MCP groups irrespective of different nationalities. In general, influencing factors and interactions existed among relevant factors in both studies which implied further investigation with multiple regression analysis is needed for better understanding.

Zusammenfassung

Seit 1998 werden Sportverletzungen von Elitesportlern in Einzeldisziplinen untersucht und überwacht. Daraus entwickelte sich das erste Überwachungssystem von Sportverletzungen für verschiedene Sportdisziplinen, das zum ersten Mal 2008 bei den Olympischen Spielen zum Einsatz kam. Verletzungen und Krankheiten, die aus dem Training resultieren können, wurden bisher noch nicht systematisch beschrieben, da die potentiellen Verletzungsfaktoren vielfältig sein können. Die vorliegende Dissertation hat zum Ziel, Fragen der Zweckmäßigkeit einer validierten Maßnahme zum Verletzungsrisiko und den damit verbundenen psychosozialen Faktoren zu untersuchen. Ausgangspunkt für die Untersuchung ist das IOC consensus statement aus dem Jahr 2009 mit den beiden Bereichen PPE und PHE.

335 Elitesportler und 88 sportmedizinische Versorger aus Deutschland und Taiwan nahmen (zwischen Oktober 2013 und Februar 2014) an einer Querschnitts- und Längsstudie (Risk-IQ und MCPQ) teil. In der Risk-IQ-Umfrage unter den Elitesportlern wurden Fragen zu vier Kategorien von Verletzungsfaktoren gestellt. Die sportmedizinischen Versorger beantworteten Fragen zu Verletzungsrisiken und psychologische Fragen. Die Antworten wurden in Skalen und Unterskalen quantifiziert, bevor sie mit anderen Faktoren analysiert wurden. Darüber hinaus wurden angepasste Variablen wie zum Beispiel das Sportformat eingeführt.

Im Vorfeld der Studie wurden die Übersetzungen der Umfragefragen validiert und Reliabilitäts-Test und Retests durchgeführt, bevor die Umfragen in Deutschland und Taiwan durchgeführt wurden. Das Ergebnis der Umfrage unter den Elitesportlern zeigt, dass die Sportverletzungen im Allgemeinen von verschiedenen Faktoren abhängig sind: Trainingserfahrungen, Leistungsniveau, medizinische Vorgeschichte, PHE und PPE Ressourcen sowie von psychosozialen Stress, der durch bestimmte Erlebnisse oder Schicksalsschläge ausgelöst werden kann. Die Art der Verletzungen werden durch die Sportart und den Trainingsort beeinflusst. Auch die medizinische Versorgung im Rahmen der PPE und PHE ist signifikant verschieden zwischen Deutschland und Taiwan.

Im Ergebnis zeigt sich, dass es anhand eines umfassenden Erhebungsinstruments möglich ist, Verletzungsfaktoren für Elite-Athleten zu identifizieren. Zusammenfassend lässt sich sagen, dass deutsche Elitesportler eine bessere medizinische Versorgung genießen als taiwanische Elitesportler. Allerdings sind sie auch von schwereren Verletzungen betroffen. Die Antworten zu den psychosozialen Einflussfaktoren gehen auseinander und lassen sich nicht auf Sportler einer Nationalität beschränken.

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Abbreviations

ANOVA	analysis of variance
CI	confidence interval
CIRS	Colorado injury report system
CVD	cardiovascular disease
DE	German/Germany
DOSB	Deutscher Olympischer Sportbund (German Olympic Sport Confederation)
EFA	exploratory factor analysis
FIFA	Fédération Internationale de Football Association (International Football Federation)
IC	international championship
ICC	intraclass correlation coefficient
IIHF	International Ice Hockey Federation
IOC	International Olympic Committee
ILE	inventory of (stressful) life event
IRB	International Rugby Board
IFs	international sport federations
MCP	medical care provider
MCPQ	medical care providers' questionnaire
NOCs	national Olympic committees
OG	Olympic Games
OTS	overtraining syndrome
PHE	periodical health evaluation
PPE	pre-participation examination
PSS	perceived stress scale
Risk-IQ	risk of injury questionnaire (for elite athlete)
RCT	randomized control trial
SCAT2	sport concussion assessment tool (version 2)
SD	standard deviation
SCD	sudden cardiac death
TC	traditional Chinese
TRR	test-retest reliability
TW	Taiwanese/Taiwan
WC	world championship
WOG	winter Olympic Games

1. INTRODUCTION

Health is the most important foundation for elite athletes' peak performance and success in international competitions. Contrarily, injury and illness, particularly severe ones, often become the most frustrating obstacles. They may cause athletes greatly from missing a competition, losing a chance to podium or even ending their sport careers. The development of injury and illness surveillance systems started in last decade with only injury data collection in major international sport competitions, extended to including illness information gathering and high risk sport identification as well in recent years (Steffen & Engebretsen 2015). However, the focus fall short only on international major sporting events. Whether there is a possibility of developing a surveillance system for monitoring longer periods of time during training phases, particularly for higher risk sports, become an issue needed to be addressed.

The International Olympic Committee (IOC) published the Olympic Movement Medical Code and made protection of athletes' health their mandate (IOC 2009). Additionally, a consensus statement for health promotion and injury prevention also issued as recommended criteria for international sport authorities and sport medicine professionals worldwide (Ljungqvist, Jenoure, Engebretsen et al., 2009; Wang 2015). International sport organization such as the Fédération Internationale de Football Association (FIFA), International Swimming Federation (FINA) and International Association of Athletics Federations (IAAF) also tried to monitor injury and illness incidences and collect medical data from athletes in major competitions (Junge, Dvorak, Graf-Baumann, & Peterson 2004; Mountjoy, Junge, Alonso et al. 2016; Alonso, Edouard, Fischetto et al. 2012). Adding these efforts together, a foundation for standardized, multi-sports injury surveillance program was set for the summer and the winter Olympic Games since 2008 (Junge, Engebretsen, Alonso et al. 2008; Engebretsen, Steffen, Alonso et al. 2010; Engebretsen, Soligard, Steffen et al. 2013; Soligard, Steffen, Palmer-Green et al. 2015). Since then, many National Olympic Committees (NOCs) and national Olympic sport delegations, followed and increasingly committed to the injury and illness surveillance program during or even before major international sports competitions in the past five Olympic Games (Clarsen, Rønsen, Myklebust et al. 2014; Palmer-Green & Elliott 2015; Steffen & Engebretsen 2015)

Accordingly, in order to complement the void from the major-competition-oriented injury surveillance systems, a counterpart measure for training phases should be established. IOC consensus statement recommended criteria for pre-participation evaluation (PPE) and periodical health examination (PHE) provided a platform for setting up an ideal injury and illness related risk factor screening mechanism (Ljungqvist, Jenoure, Engebretsen et al. 2009). However, up to date, due to technological challenges and time requirement in investigation during training involved with heterogeneous elite athletes cohorts, there is no standardized instrument available for athletes' PPE and PHE from IOC's recommended protocols developed; let alone a multi-disciplinary integrated, standardized evaluation instrument for injury risk factor investigation targeting particularly for training backgrounds. Therefore, the relationship between different risk factors and their possible effects are not yet completely understood. Further, even though the instrumental value of PHE and PPE is well recognized, however, the feasibility of creating a validated and effective comprehensive injury surveillance instrument for training is yet unclear due to many potential moderating effects and interactions might exist (Bahr & Holme 2003, Wiese-Bjornstal, Smith, Shaffer, & Morrey, 1998) and need to be clarified.

The time and tasks needed for this mission seems to be long and overwhelming. Nevertheless, two questionnaires (Risk-IQ, and MCPQ) were created and validated for international surveys in this study as attempts to explore as many possible injury/illness related risk factors for these goals. Factors of four domains (orthopaedic, carvascular, psychosocial and training environmental factors) were emphasized in thses two questionnaires. Apparently, it was not possible to include all necessary steps and solve all problems related to injury risk factors issues by this present thesis. However, it was author's aim to start this study as first step toward the direction for final solution.

2 LITERATURE REVIEW

2.1 Evolving trend and research focus on injury and illness of elite athletes

Injury and illness has been always the greatest concerns for elite athletes, sport medicine professionals, stakeholders as well as related personsonnels around athletes. A severe injury or illness can be an unfortunate event for top-level athletes from missing a competition, missing a medal, or even ending his/her career. The physical, emotional as well as psychosocial set back from an injury or an illness incident can be seen easily in above-mention situations, yet the causes and reasons are not all self-explanatory or easily understood. Due to the prevalence of injury and illness and the complexity of its risk factors, research of injury prevention on mechanism and risk factor identification has been an international common focus for sport medicine and sport science teams (Peterson, Junge, Chomiak, Graf-Baumann & Dvorak 2000; Bahr & Krosshaug 2005; Corrado et al. 2008; Engebretsen & Bahr 2009; Soligard et al. 2015). Over years, sport medicine researchers conducted different projects aimed to solve various research questions with sport athletes in all types of sports and levels of physical performance under diverse conditions, from personal traits to psychosocial stresses (Siegrist & Geyer 2014); and from age groups and skill levels (Peterson et al. 2000) to individual sport types (Häggglund, Waldén & Ekstrand 2009; Yung, Chan, Wong, Cheuk & Fong 2007). However, a systematically, multi-disciplinary integrated, comprehensive research results were rarely reported.

On the other hand, since first injury and illness surveillance system set up in a single-sport international competition in 1998 (Junge et al. 2004), International Olympic Committee and International Sport Federations (IFs) have been gradually building bigger surveillance networks and databases for Olympic Games and for IFs' world championships (Soligard et at. 2015; Engebretsen et al. 2013; Engebretsen et al. 2010; Alonso et al. 2012; Junge et al. 2009; Dvorak, Junge, Grimm & Kirkendall 2007; Torjussen & Bahr 2006). This development set the foundation for the multi-sports injury and illness surveillance program in summer as well as winter Olympic Games since 2008 (Junge, Engebretsen, Alonso, et al., 2008; Engebretsen, Steffen, Alonso, et al. 2010; Engebretsen, Soligard, Steffen, et al., 2013; Soligard, Steffen, Palmer-Green, et al. 2015).

However, such injury surveillance systems were conducted only in major international sport events, as van Mechelen commented, it does not fit for all situations (van Mechelen, 1997) especially for athletes in their non-competition training phases. Notably, recent development of a new approach focused on overuse/over-training related injury and illness, allowed team physician as well as athletes and coaches to prospectively monitor injury and illness of elite athlete during training phases with better accuracy compared to standard injury surveillance methods (Clarsen, Rønsen, Myklebust et al. 2014; Clarsen, Myklebust & Bahr 2013). On the other hand, electronic version surveillance system through mobile applications, as researchers reported, still facing scientific challenges on its evidence basis (van Mechelen, van Mechelen & Verhagen 2014).

2.2 Theory and model of sport injury/illness risk factor research

Risk factors of elite athletes' injuries and illness are often complex, multi-factorial and cover a full spectrum of different aspects in one's lifespan. Along with the advance of sport medicine and science overtime, the focus of sport injuries and illness prevention research also generated a greater span and more diverse interests, particularly on injury prevention, injury mechanism and risk factor identification. Many sport injury/illness related theories and models had developed in psychosocial, biomechanical as well as medical domains respectively.

In terms of risk factor analysis and injury mechanism identification, a dynamic multifactorial model of sport injury risk factors analysis first portrayed by Meeuwisse (1994) and later adapted by Bahr and Holme (Figure 1. 2003) categorised the characteristics of potential risk factors into internal factors vs. external factors before the triggering condition(s) were encountered. Personal medical, biomechanical, psychosocial factors as well as external training and competition related environmental factors all included in this model. By following the logical attribution of Bahr and Holme's model, all potential injury risk factors can be specifically identified and generally categorised into three groups (internal risk, exposure to external risk, and inciting event) which may help researcher to tackle particular factor(s) for the designing of injury preventive training and/or rehab programs (Bahr & Krosshaug 2005).

A paradigm named Haddon's Matrix (Runyan 1998) is a matrix with three phases (pre-injury, injury, post-injury) and four columns (human, vehicle/equipment, physical environment, and social-economic environment) with all characteristics of the setting, originally devised for injury preven-

tion and management for motor vehicle traffic accident, has been adapted for injury prevention in sport (Leadbetter, 1992).

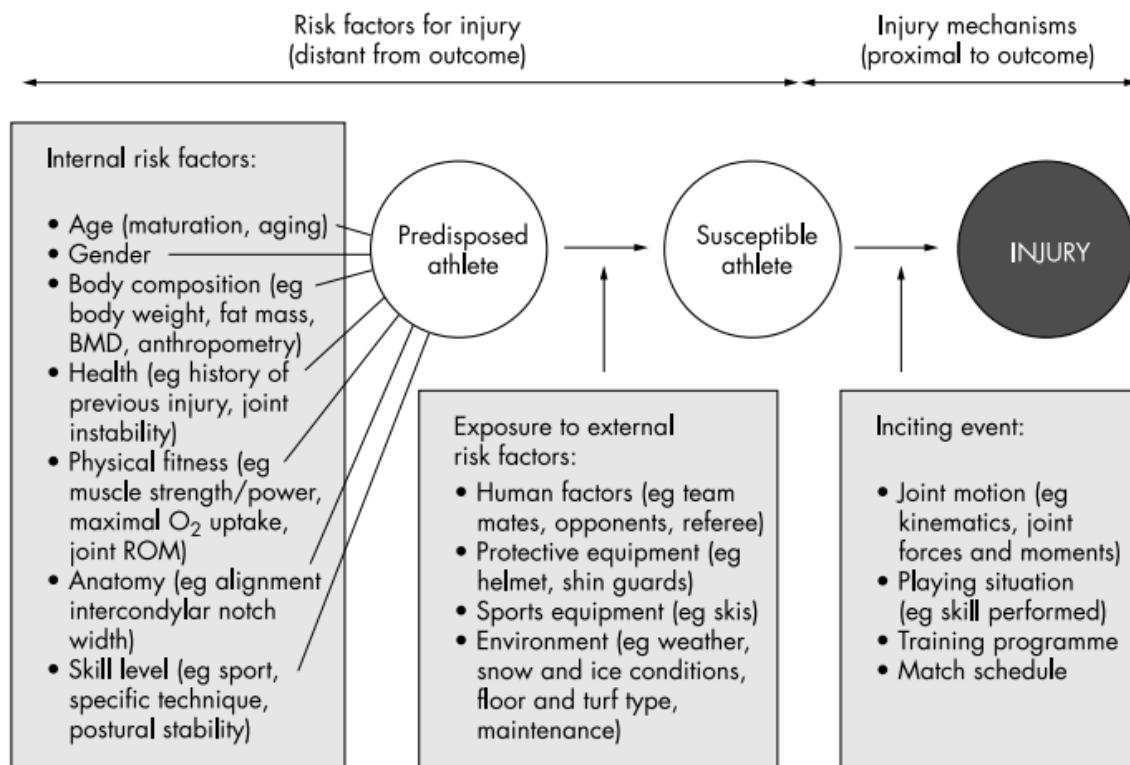


Figure 1. Sport injury risk factors model adapted by Bahr and Holme (2003)

In terms of establishing an effective “risk-identification and injury prevention” operational procedure, the 4-step injury prevention model (Figure 2) proposed by van Mechelen, Hlobil and Kemper (1992) has been widely accepted. This cyclical 4-steps conceptual pattern including the analysis of 1) incident & severity, 2) aetiology & mechanism; followed by introducing of 3) preventive measure, and 4) effectiveness assessment. A later development based on this 4-step model, Finch updated with a 6-steps procedure called “Translating Research into Injury Prevention Practice” (TRIPP) model (Figure 3. Finch 2006) which consists of two extra steps in the procedure : 5) describe intervention context to inform implementation strategies, and 6) evaluate effectiveness of preventive measure in implementation context. These two extra steps may provide more operational specificity and thus promote the effectiveness of the injury preventive program.

These injury risk management tools can be utilized by sports governing bodies, sport medicine scientist and athletes as well, to identify preventive and therapeutic interventions in order to decrease the frequency of occurrence and/or severity of injuries within particular sports (Fuller & Drawer 2004; Finch 2006; Steffen, Soligard & Engebretsen 2012).



Figure 2. Four-step model from van Mechelen et al.(1992)

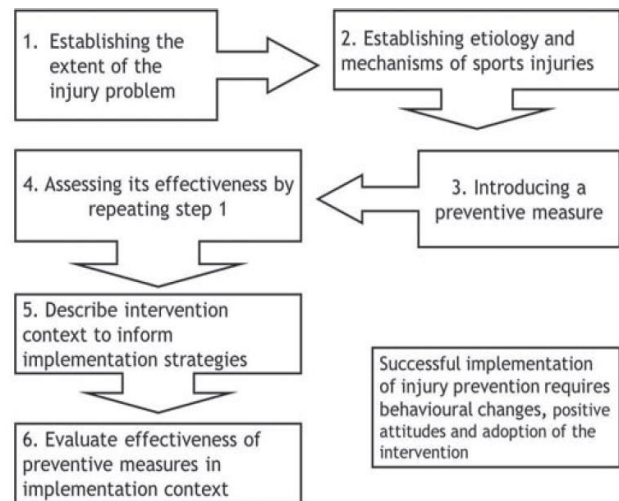


Figure 3. Six-step TRIPP model from Finch (2006)

In terms of psychosocial aspects, two main theories namely Life Span Theory and Accumulation Effect were the centred hypotheses for most of the studies on the relationship of stressor and sport injury (Wippert 2011). Andersen and Williams proposed a model of “Stress-injury Relationship” (Figure 4.) provided a theoretical foundation for psychosocial related factors of sport injury researches and reviewing (Williams & Andersen 1998; Junge et al. 2000). Notably, this model also included interventions for longitudinal study for reducing injury risk. Accordingly, the development of Holmes and Rahe’s Social Readjustment Rating Scale (Holmes & Rahe 1967) was accredited as the pioneer study between top level athletes’ injury/illness and their stress level from life events (Williams & Andersen 1998) which lead to many applicational studies on top level of athletes’ injuries.

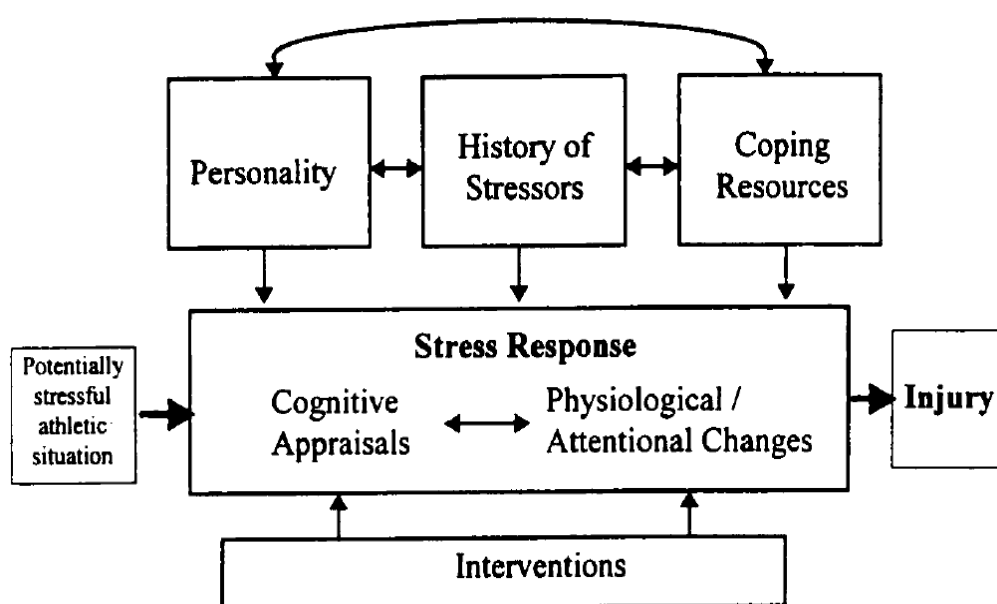


Figure 4. Revised version of the sstress and injury model (Williams & Andersen, 1998)

It is an essential element to have a fundamental theory-based framework for sport injury/illness research before taking series of comprehensive measures with multiple aspects from athletes-centred environment and background. In the past, most researches on the topics of injury risk factors identification focused on either only single risk factor, or only single top athlete cohort or only non-elite athlete cohorts.

2.2.1 Medical aspects risk factor and PHE/PPE

Literature of medical related risk factors considered in this study mainly covered in two aspects namely Musculoskeletal Risk Factors and Cardiovascular Risk Factors which were intentionally corresponding with the IOC consensus statement and focused on two organized protocols: Periodic Health Examination (PHE) and Pre-Participation Evaluation (PPE).

2.2.1.1. Musculoskeletal risk factor and PHE/PPE

Various groups studied on injuries of different body parts concluded that the previous history of injury was the most relevant risk factor for recurrent injuries (Häggglund et al. 2006; Waldén, Häggglund & Ekstrand 2006; Croisier 2004, Garrick 2004; Matheson et al. 2005), therefore, the past injury record and history can be used as a predictable criteria for PHE and PPE. Biomechanical and anthropometric discrepancies between normal and injured athletes appear to be a commonly encountered problem in literature related to PHE and PPE (Murphy, Connolly & Beynnon 2003; Fong, Hong, Chan, Yung & Chan 2007; Maffey & Emery 2007). Other PHE and PPE relates musculoskeletal related risk factors (moderators) needed to be screened including but not limited to: sport type/discipline (i.e. winter Olympic sports vs. summer Olympic sports) for core-instability related injury (Leetun, Ireland, Willson, Ballantyne, & Davis 2004; Emery & Meeuwisse 2001); sport format (i.e. contact/combat sports vs. non-contact/non-combat sports) for concussion and severe injury (McCroy et al. 2009; Orchard 2001); skill level (i.e. competition experience levels (i.e. novice vs. veteran) for overused injury and severe injury (Croisier 2004; Häggglund et al., 2006); and performing pattern (printing, jumping, landing, swinging, with object impact) related injury (Brockett, Morgen & Proske 2004; Verrall, Slavotinek, Barnes, Fon & Spriggins 2001; McKay, Goldie, Payne, & Oakes 2001).

2.2.1.2. Cardiovascular risk factor and PHE/PPE

Literature of injury/illness related risk factors for elite athletes showed that only “cardiovascular risk factor screening” alone already involved a wide spectrum of factors (Thünenkötter, Schmied, Dvorak, & Kindermann, 2010). Research topics related to cardiovascular risk factors and PPE are generally categorized by author in 3 categories namely: 1 <*Cardiovascular disease (CVD) risk factor screening and CVD prevention*> With 30+ years long pioneer investigations on cardiovascular risk factor screening, PPE for sport, sport license program, and related researches were conducted by European (Italian) cardiologists, which directly contributed to the lowest Italian national sudden cardiac death (SCD) rate among European countries and establishment of PPE cardiovascular criteria in IOC consensus statement 2009 (Maron et al. 2007; Pelliccia et al. 2005; Pelliccia & Maron 1995; Corrado et al. 2008; Corrado et al. 2003; Corrado et al. 2005; Bille et al. 2006; Moron 2003). 2 <*Interpretation and accurate diagnostic transition*> Whether adapting the traditional 12-lead ECG method or the advanced echo-cardiac ultrasound method for baseline cardiac function and stress performance evaluation, accurate and effective diagnostics interpretation are both required, which involved with appropriate training, practice on sufficient medical resource and support, Corrado & McKenna (2007) argued that a reversion of interpretation of athlete’s 12 lead ECG, with proper and accurate training, will deliver the goal and save unnecessary financial cost whereas Lawless and Best (2008) advocated an interpretation scheme and decision tree for more accurate ECG-based screening protocol. 3 <*Criteria and standard protocol for cardiovascular screening in PPE*> Two main schools (European vs. US) of cardiologists are constantly exchanging most updated research findings on cardiovascular risk screening criteria and protocol (for qualification/disqualification of competitive athletes) to be adapted as standard PPE procedure (Corrado et al. 2005; Pelliccia, Zipes & Maron 2008, Drezner et al. 2013). Recently, Riding and colleagues reported their 2014 refined criteria had outperformed both 2013 Seattle Criteria and 2010 European Criteria by significantly reducing the number of false-positive ECGs in Arabic, black and Caucasian athletes while maintaining 100% sensitivity for serious cardiac pathologies. (Riding et al. 2015).

2.2.2 Psychosocial factor – stress and life events

Psychosocial factor of stress from life events have been considered as an important antecedent to the onset of athletic injuries. Referring to Andersen and Williams’ Stress – Injury Relationship model, groups of sport medicine professionals and scientists have investigated the psychological characteristics as well as social environment as risk factors for elite athlete injury and illness

(Steffen, Pensgaard, & Bahr, 2009; Wiese-Bjornstal et al. 1998). Perceptual change also taken into account for psychosocial factor of sport injury by Andersen and Williams (1999).

As psychosociological theory based instrument such as the *Social Readjustment Rating Scale (SRRS)*, *Inventory of Life Event (ILE)* has been utilized since 1970s and proved by many studies as highly relevant to the incidence of injury (Siegrist & Geyer 2014). Empirical results have been reported and supported the argument that higher life-event stress is significantly and positively correlated with athletes' injury and illness (Perna & McDowell 1995; Wang, Mayer & Wippert 2015b; Wang, Rector, White & Mayer, 2015d). Researchers considered the psychological factor can also play an important role in injury rehabilitation and ultimately successful return-to-play (Cramer-Roh & Perna 2000, Mann, Grana, Indelicato, O'Neill & George, 2007). Psychosocial stress from life events can not only be used as a predictor for sport injury risk for top level athlete (Ivarsson, Johnson, Podlog 2013; Sibold, 2004; Galambos, Terry, Moyle & Locke, 2005) but also be adapted as measure for a stress management program (Kerr & Goss, 1996)

2.2.3 Training and environmental factors

One of the most predominated factor of injury/illness during the training period is overtraining syndrome (OTS) related risk. Several studies and reviews on various sport types of elite athlete cohorts reported with same conclusion (Winsley & Matos 2011; Purvis, Gonsalves & Deuster 2010) that one common trait among these reported syndromes and complaints involves with endurance/aerobic sports or prolonged exercise tasks under excessive demands. Other syndromes from OTS including but not limited to: increased perception of effort during exercise (Halson 2014), frequent upper respiratory tract infections (Schwellnus, Lichaba & Derman 2010; Nieman, 2000), muscle soreness, sleep disturbances, loss of appetite, mood disturbances, and decreased interest in training and competition (Winsley & Matos 2011) and more other injury/illness risk related syndromes. However, the identification of real mechanism and cause of OTS is considered difficult, as Purvis and colleagues concluded, due to complex interrelationships among psychological, social, physiological profiles, dietary patterns and the neuroendocrine, immune and central nervous systems (Purvis et al. 2010).

An consensus statement on training load in sport and risk of injury was issued after IOC convened groups of experts for reviewing of scientific evidence. Athletes with higher training loads, saturated competition calendars, high traveling demands, psychological load, and poor load management

are considered to pose higher risk for injury. Such statement serves as a guideline for athletes, coaches and support staff for the purpose of prescription of training and competition load, as well as monitoring of athletes' injury and well-being (Soligard, Schwellnus, Alonso et al. 2016)

European College of Sport Science (ECSS) published two consensus statements namely: Over Trained Syndrome (Meeusen et al. 2006) and Prevention of Acute Sport Injury (Steffen et al. 2010), both statements addressed the issues of elite athletes' training environment and training conditions by providing clarified definition, recommended check list and necessary procedures as well as inclusive and exclusive indications. Both consensus statements meant to be shared and used by all elite athlete injury/illness related stakeholders as a general criteria and standard. Further, future recommended directions for research and development were also shared from both statement developing teams.

Risk of injury and illness from sport training background is sport specific as Lawrence and colleagues pointed out that elite athletes who participated in longer and more intense training had higher incidence rates of low back pain (degenerative disk disease and spondylolysis) than athletes who did not participate (Lawrence, Greene & Grauer 2006). Wang and colleagues also reported a similar result from a back pain/injury focused analysis of elite athletes and concluded the higher back pain/injury rate was associated with sport types, particularly in sports with combat format and sports performed on ice (Wang, Appiah-Dwomomh, Silis, Mayer & Wippert 2015c).

2.3 Methodology and approach of sport injury/illness risk factor study

Besides the fundamental difference between the established injury surveillance systems for multi-sport international competitions and the not-yet-defined, no consensus existed injury reporting system for training phases, there are still many crucial issues can potentially compromise researcher's effort for an accurate and consistent sport injury/illness risk factor study. Fuller and colleagues argued the importance of reaching consensus among researchers and scientists on the definition of sport injury and the procedure of data collection, particularly for specific sport event and discipline (i.e. football) in order to allow inter-study comparisons possible and meaningful (Fuller et al. 2006). Brooks and Fuller further demonstrated how the result of sport injury can be presented with bias when the injury data from training and from competition were combined differently, thus, they supported the clearer definition of injury, recurrent injury and method of calculating incidence (Brooks & Fuller 2006). Further, Gabbe and colleagues pointed out the limitation of adapting self-report injury record for sport injury research. According to their 1-year long

retrospective-and-prospective combined study, approximately 80% accuracy rate about injury frequency and injured body region was reported. However, when the record requires detailed information such as extra number and diagnosis, the accuracy rate dropped to 61% (Gabbe, Finch, Bennell & Wajswelner, 2003). These points are practically valuable for the planning and execution of a sport injury and illness related study.

2.3.1 Criteria and standardization of consensus statement as evaluation tool

Chronically, there were a few “consensus statements” published by various professional sport medicine organizations, directly or indirectly correlate to this study. In author’s point of view, the importance of these consensus statements is the precursor roles they play that may lead to development of standardized criteria. Started in 2001 up to 2008, the consensus agreement of concussion in sport (or Zurich concussion consensus statement) was delivered by a four-parties collaboration between International Ice Hockey Federation (IIHF), International Olympic Committee (IOC), Fédération Internationale de Football Association (FIFA), and International Rugby Board (IRB), concluded and updated with the second as well as third versions of Sport Concussion Assessment Tool (SCAT2, SCAT3) and recommended to be used by physician, therapists, athletic trainer, health profession (and for non-medical professions such as coaches and athlete the Sport Concussion Recognition Tool was recommended) (BJSM, 2013). The “pocket” & “check-list” styles of SCAT2 and SCAT3 deal with sport concussion related issues such as symptoms and sign of acute concussion, definition and classification of concussion, on-field and sideline evaluation, cognitive and physical evaluation as well as return to play information. As an un-standardized measure, SCAT2, SCAT3 was further recommended for investigation on relevant topics and for validation (McCrory et al. 2009).

Among many health protection and injury prevention consensus statements published by IOC, the consensus statement for non-contact ACL injury in the female athlete (Renstrom et al 2008) is one good example showing how the agreement on risk of non-contact ACL injury from a group of sport scientists and medicine experts can provide criteria for injury mechanism identification, risk factor screening, and direction for injury prevention program cooperation between sport authority, medical professional, athletes and coaches. The IOC consensus statement in 2009 (Ljungqvist et al., 2009) was essentially a recommended protocol for execution of PHE and PPE for international sport authorities and sport medicine professionals. However, these expert-opinion-based referential procedures and check lists has not been standardized into an evaluation instrument for injury and illness risk factor (Wang 2015), which is the main task of this study. Risk of injury question-

naire for elite athlete (Risk-IQ) was the product of the authors' attempt to standardize the checklist style sport injury and illness related criteria (Wang, Mayer & Wippert 2015a).

Besides IOC, the European College of Sport Science (ECSS) also published many consensus statements related to elite athletes' health promotion and injury prevention issues such as Over Training Syndrome(OTS) (Meeusen et al. 2006), and Prevention of Acute Sport Injury (Steffen et al. 2010) as described in 2.2.3 Training and environmental factors section.

2.3.2 Concerns of cultural and linguistic differences and barriers

The two main elements (PPE and PHE) of the IOC consensus statement 2009 has not been standardized before this PhD work started with the "Risk-IQ" project in 2012, the standardization process for the new questionnaire requires factor analysis of included items and scales and test-retest reliability evaluation. Tests for translation reliability as well as cross-cultural relevance also necessary if any another language or culture is involved (Beaton, Bombardier, Guillemin, & Ferraz, 2007). Translating of an instrument procedure simply from one language word-to-word into another language is inadequate to account for linguistic and cultural differences. Four elements, including content, semantic, technical and conceptual should be considered in order to reach the highest level of reliability in cross-cultural translation (Lee, Li, Arai, & Puntillo, 2009). In addition, Harkness and colleagues proposed that when measures are to be used in different languages, the items of the evaluation tool must not only be translated well linguistically, but also culturally adapted to maintain the content validity of the instrument at a conceptual level across different cultures (Harkness, Pennell, & Schoua-Glusberg, 2004). Theories and methods evaluating reliability of translation have been adapted for different research contents and goals. Brislin (1970) suggests a "backward and forward" translation process for instrument to be used in cross-cultural research while McDermott & Palchanes (1994) recommended that at least two independent bilingual translators should perform the translation.

2.4 Medical care resources and elite athletes' health protection

De Bosscher and colleagues conceptualized all the possible contributing factors to international Olympic success with a 9-pillars model which include the support (research) of sport science and sport medicine as one of the 9-pillars (de Bosscher et al. 2008). This model revealed the reality of great diversities exists among compared nations in terms of the quantity and the quality in nation-

al medical care support systems. This notion also supported by Green and Haulinhan from their international literature reviewing, in which they concluded that the provision of coaching, sport science and sports medicine support services, although highly variable in both quantity and quality, is one of the 4 core elements for national preparation of international sport events (I.e. Olympic Games) (Haulihan & Green 2008).

Since October 2009, the Olympic Movement Medical Code (IOC 2009) was put in force by IOC to promote health and prevent injury/illness of elite athlete worldwide through the cooperation of global networks of NOCs and IFs. Under IOC's encouragement, many NOCs and ISFs members adapted and followed the IOC recommended protocols for PHE and PPE in national sport medicine systems which including medical care services for elite athlete inside and outside of training centres. However, not all NOC or ISF members can always keep up with these higher standards due to many different reasons such as governmental policy and/or priority, financial or medical care resources etc.

German sport medicine system, on one hand, is a good example which following IOC recommended PPE and PHE protocols and therefore good case for international comparison; on the other hand, sport medicine and medical care resource for elite athletes in Germany provided by Olympic training centres, DOSB certified medical centres as well as national sport federations, are built on the basis of Basic Law (Article 30) (Petry, Steinbach & Burk, 2008) therefore, there is a systematic difference relatively to many other countries without such legal basis. However, as de Bosscher's model pointed out, the causes behind a successful Olympic program does not only reply on governmental funding alone. Thus, there are still lacks of knowledge regarding the complex relationships between the medical resources/policies and multifaceted injury and illness risk factor screening measures. Nevertheless, when the definition of a success program focus only on health protection and injury prevention for elite athletes, Hanstad and colleagues demonstrated how a better prepared medical care teamwork and service program can produce positive impact and effectively reduce injury/illness incident rate on Norwegian national delegation for Winter Olympic Games (Hanstad et al. 2011).

2.5 Influence of MCPs' perspective on injury & rehabilitation related issues

Numerous authors had indicated that medical care providers' (MCPs) decisions in handling athlete health or injury related issues are often considered as significant influencing factors to the result of injury and rehabilitation related studies (Herring et al. 2007, Brooks & Fuller 2006. Pearsall, Ko-

valeski & Madanagopal 2005). The roles that MCPs playing could be as an investigator, a handler, an evaluator and sometimes a definition-giver (i.e. severity level of injury) in each athlete's injury case. Nevertheless, MCPs for elite athlete health care services in fact involves different medical professional cohorts with different educational and training backgrounds, as well as various experiences on PHE/PPE related job assignments and expected tasks in their professional positions, which also meaning the interactions between athlete-patients and various MCP cohorts are often multi-facets and interactive (Mann et al. 2007). However, there is still a void of knowledge in literature on systematic investigation of the effects and interaction from various MCP cohorts to elite athlete injury related issues, and a lack of knowledge on the effect of existed differences from medical care systems and overall environment between countries on their elite athletes' PHE/PPE medical care services.

Psychosocial factors have been shown to be an important antecedent to the onset of athletic injuries and also play an important role in injury rehabilitation and ultimately successful return-to-play. (Cramer-Roh & Perna 2000, Mann et al. 2007). However, recent studies pointed out the potential interactions between psychosocial factors of athletes and MCPs' perspectives on injury prevention and post-injury rehabilitation were often left out from recommended protocols (Herring et al. 2006, Cramer-Roh & Perna 2000).

3 . RESEARCH OBJECTIVES

The feasibility of a multi-disciplinary integrated approach based on IOC consensus statement recommended criteria (PPE & PHE) as effective evaluation measures become the first and foremost focus for this PhD study. With such validated instrument, investigation can be conducted for inter-relationships among risk factors and further developed into injury prevention and rehabilitation strategies. In order to conceptualize these potential inter-relationships among elite athlete injury/illness risk factors (in training periods) and help setting operational procedures for series of works in this study, author proposed a multi-factorial four-phase flow diagram (Figure 5.) as the framework.

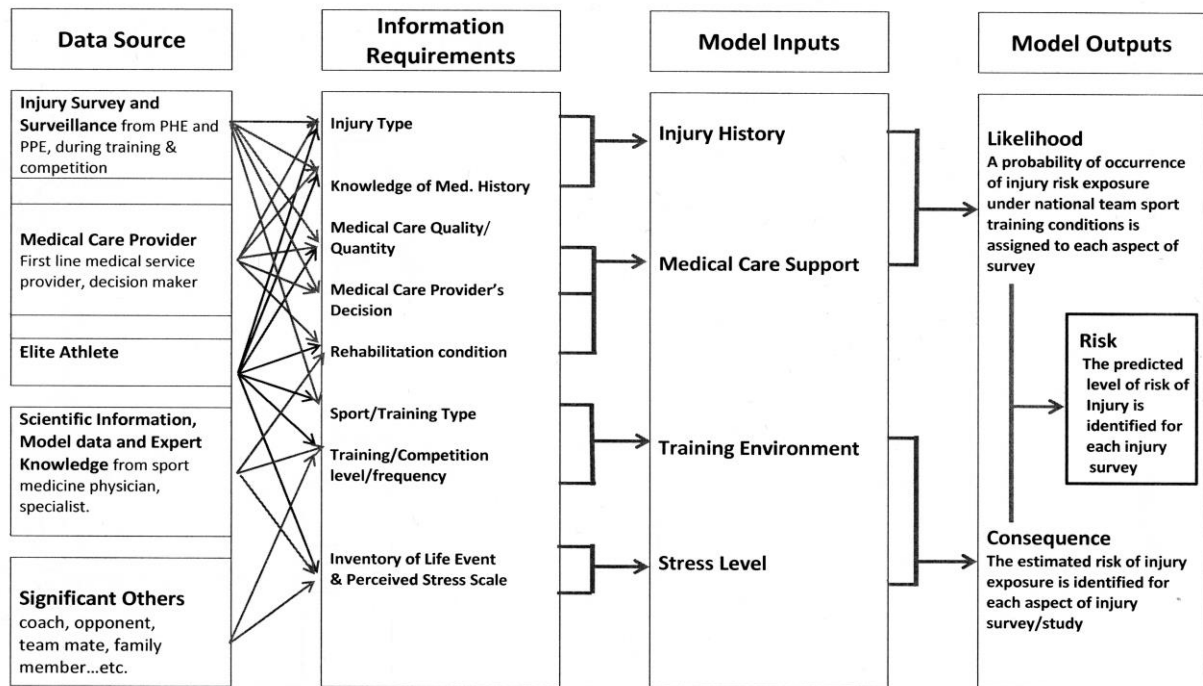


Figure 5. Four-phase flow diagram for elite athlete sport injury risk factors analysis

This four-phase flow diagram meant to demonstrate the operational directions of tasks and inter-elemental relationship in each phases. Simply judging from viewing, the potential interaction(s) between elite athletes and their medical care provider regarding the injury and risk factor related information are likely exist between phase-1 (data source) and phase-2 (information requirements) as the hypotheses of these research projects suggested.

This PhD project was focused on the acquisition of fundamental knowledge of injury related information (phase 1) from related sources, and through further analysis, to establish the aetiology, mechanism of risk factors in general and in specific conditions (as task describe in TRIPP model-step 2); aiming to provide fundamental information for risk-factor-specific intervention and training program for injury prevention (TRIPP model-step 3); and to provide program effectiveness assessment (TRIPP model step 4-6) for different potential partners within the Olympic Family (ISFs and NOCs).

Based on these goals and procedures, the research objectives of this thesis regarding the injury and illness risk factor for elite athlete in training environment can be summarized as the following:

- I. The first objective (study 1) was to develop a functionally and linguistically valid risk injury evaluation tool to be used in different countries. The specific aims of this study were:
 1. To develop a risk injury questionnaire (Risk-IQ) for elite athlete which was based on the PHE and PPE criteria described in the IOC consensus statement.
 2. To investigate Risk-IQ's validity and test-retest reliability within German and Taiwanese elite athletes
 3. To assess the Risk-IQ's translation reliability between two different countries and languages (German and Traditional Chinese).
- II. The second objective (study 2) was to evaluate risk factors and medical care support for better understanding of the relationship between risk factors and their associated effects. The hypotheses were:
 1. There are differences between injury related factors within German and Taiwanese elite athletes.
 2. These injury related factors can significantly influence the injury frequency
 3. In both cohorts there are interactions within these risk factors.
- III. The third objective (study 3) was to investigate the relationship between injury and illness risk factors and MCPs' opinion and handling on those factors. It was hypothesized that:
 1. There are a) significant differences of PPE & PHE scales between German and Taiwanese MCP cohorts and these differences are related to their b) medical education/trainings, c) medical care job positions, and d) experiences levels.
 2. There are significant differences among MCP cohorts' usages and perspectives of

psychosocial factors during athlete's injury and rehabilitation treatment.

3. There are significant correlations between employed scales and MCP related influencing factors.

Table 1 Characteristics of the studies included in the present thesis.

Study	Journal	Design	Participants	Measures	Chapter
1	Sports & Exercise Research (peer reviewed)	cross-sectional	Pilot study: N= 46, F (n=27), M (n=19); mean age: 26±6.7 ys.	Questionnaire reliability, factor analysis of Risk-IQ	5.1
		cross-sectional	TRT study: N= 62, F (n=21), M (n=41); mean age: 22.1±3.2 years	Construct validity. TRT reliability, translation reliability of Risk-IQ	5.1
2	Gazzetta Medica Italiana (peer-reviewed)	cross-sectional & retrospective	Total N= 335 Germany: 66, mean age: 26±7.6 years Taiwan: 269, mean age: 23.2.1±6.9 ys.	Injury risk factors (cardio-vascular, orthopedic, psychosocial, and training environmental), injury frequency, correlation, interaction	5.2
3	Sports & Exercise Research (peer reviewed)	cross-sectional & retrospective	Total N= 86 Germany: 34, mean age: 36.3±8.2 years Taiwan: 52, mean age: 36.9±10.3 years	Descriptive statistics, significant difference, correlation of factors in MCPQ	5.3

TRT = test-retest, Risk-IQ = risk of injury questionnaire for elite athlete, MCPQ = medical care provider questionnaire, F = female, M = male

Publication Awards

Best Presentation Award (Oral presentation)

IX International Baltic Sports Medicine Conference Tartu, Estonia, August 2015

Wang, V.C., Appiah-Dwomoh, E., Silis, M., Mayer, F., Wippert, P.M. (2015c). Is elite athletes' back pain & injury "sport type specific"? Oral presentation in IX International Baltic Sports Medicine Conference. 20-23 August, 2015, Tartu, Estonia. Abstract book p 14

First Prize Award (Oral presentation)

European Sport Medicine Congress, Antwerp, Belgium, September 2015

Wang, V.C., Rector, M., White, S., Mayer, F. (2015d). Correlation and interaction of stress factors and injury related scales in the risk of injury questionnaire (Risk-IQ) for elite athlete. *European Journal of Sport Medicine*. 3(S1) p62-63.

4. METHODOLOGY

4.1 Subjects and Participants

4.1.1 Elite athlete

Pre-Study: 46 German sport students were recruited from sport related department of the University of Potsdam. Inclusion criteria including having German as mother-tongue language skill without any difficult understanding questions in the draft version questionnaire; college level sport related major students or athletes with basic understanding of sport injury and medical terms.

Pilot-Study (Test-retest Reliability) 35 German (19 female, 16 male, age 21.5 ± 3.5 and 28 Taiwanese (3 female, 25 male, age 23 ± 2.8) were recruited from sport related department of the University of Potsdam and the National Taiwan Sport University. Inclusion criteria including having German (for Germany) or Chinese (for Taiwan) as mother language skill without any difficult understanding questions in pilot version Risk-IQ; college level sport students and/or athletes (but not national team member) with basic understanding of sport injury and medical terms. Physical activity level: 2-3 hours per session, 2-4 sessions per week of sport related activities.

Main-Study (official version Risk-IQ): 269 Taiwanese (121 female, age= 22.7 ± 5.6 ; 148 male, age= 23.6 ± 7.8) and 66 German elite athletes (32 female, age= 24.0 ± 5.9 ; 34 male, age= 27.9 ± 7.8) were qualified and engaged in the study. Inclusion criteria including having German (for Germany) or Chinese (for Taiwan) as mother language skill; athlete of national team member or candidate, currently training (or had trained or retired from) for international level sport competitions of Olympic sport. The demographic information (gender, country and age) of elite athletes cohorts listed in Table 2.

Table 2. Elite athletes' background information

By Gender	female: N=151(45.1%)	male N=184(54.9%)
By Country	Taiwan: N=269 (80.3%)	Germany: N=66 (19.7%)
By Age	Taiwan 36.9 ± 10.3 years	Germany 36.3 ± 8.2 years

The age differences between male German and male Taiwanese athlete cohorts reached significant level ($p < .05$); while the age difference between female cohorts from both countries show no significance. (Table 3)

Table 3. Elite athletes' age stratified by gender and by country factors

	female	male
Taiwanese	N=121, 22.65± 5.6yrs age range 12-45	N=148, 23.57± 7.8yrs, age range 13-40
German	N=32, 23.97± 5.6 yrs, age range 16-40	N=34, 27.94± 7.8yrs, age range 18-42
Overall	N= 153, 22.93± 5.9 yrs, age range 12-45	N=182, 24.39± 7.9 yrs, age range 13-55

Thirty-eight different Olympic sport types/events were recruited for this study, however, in order to provide different perspectives with more robust statistic power, two adapted sport types categorization systems were employed. Based on the format of sports, the Adapted Sport Type_1 categorized the recruited Olympic sport types into 5 groups namely: “individual no-contact”, “individual combat”, “team no-contact”, “team contact” and “team combat”. Based on the location of locomotion happened, the Adapted Sport Type_2 categorized the recruited Olympic sport types into 4 main categories namely “on land”, “in/on water”, “on snow” and “on ice”

4.1.2 Medical Care Providers

Medical Care Provider (MCP) Study: 52 Taiwanese (age 36.9± 10.3) and 34 German (age 36.3± 8.2), 41 female, 45 male, were recruited in the study. Inclusion criteria including havinf German (for Germany) or Chinese (for Taiwan) as mother language language skill; medical care related professional who had previously provided medical service to international level athlete in the past. Medical education/background, service location and years of experience were not specified as long as medical care related professional services were at least once provided to elite athlete whose qualification defined as in Risk-IQ –main study.

4.2 Study procedure

There are four different phases (Figure 6) involved with seven different cohorts in this study, first in pre-study phase, a Geman cohort of college sport student and athletes (N=46) were recruited for initial version questionnaire development. Second phase was the pilot study, two cohorts of college level sport student and athletes were recruited from both Germany (N=35) and Taiwan (N=28) for questionnaire’s test-retest reliability. Third phase was the main study, two cohorts of elite athletes from both Germany (N=66) and Taiwan (N=269) who has been trained (or had trained / retired from) for national team of Olympic sports were recruited for official survey.

The final phase was for the official survey of the medical care providers, two cohorts of medical professionals were recruited from Germany (N= 34) and Taiwan (N=52)

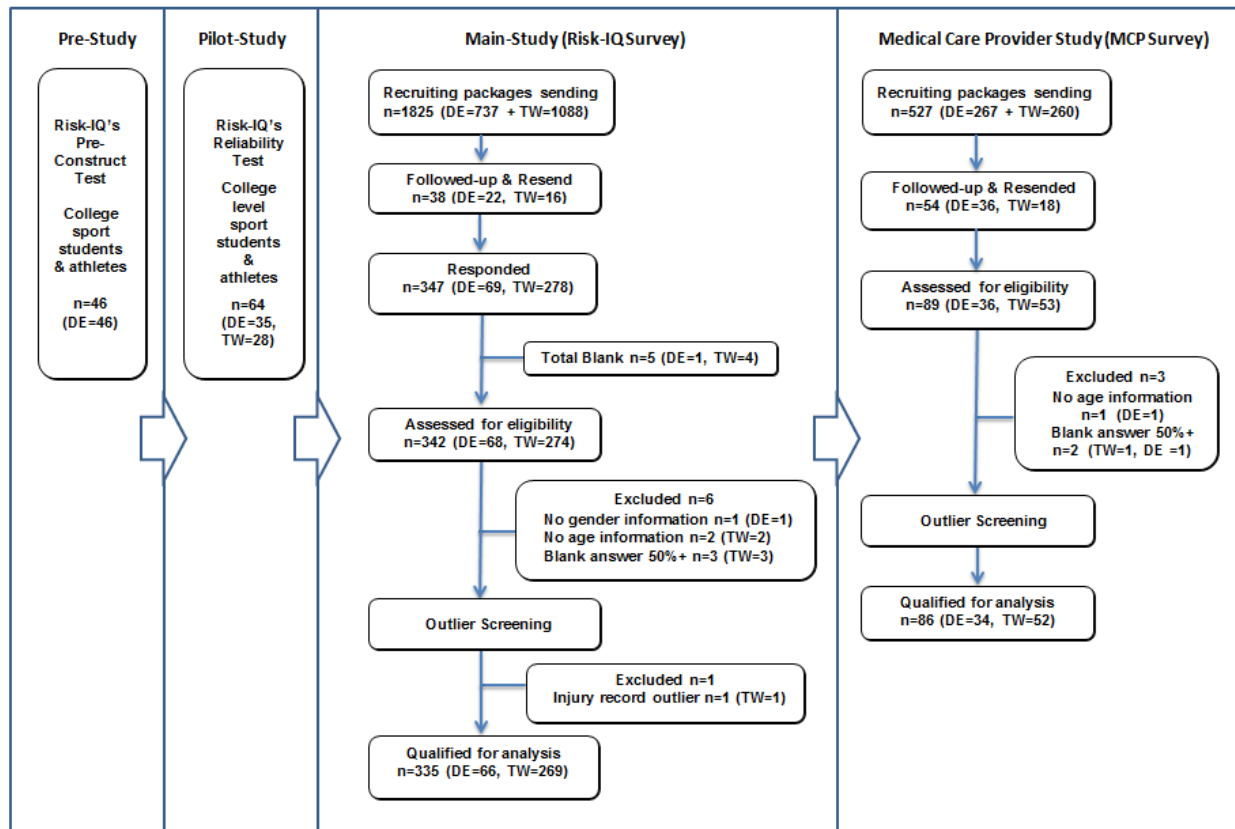


Figure 6. Four-phase flow diagram for study sub-projects and data collection procedures

4.3 Recruiting Procedure

Risk-IQ project

The recruiting process for elite athletes of Risk-IQ project started from mid-August, 2013 in Taiwan and Germany simultaneously, ended in end of February, 2014 for Taiwan, end of May for Germany. Targeted organizations on recruiting lists including: Olympic sport training centers, national sport federations, national delegations of Olympic sport teams. For Germany, adding national and regional sport clubs where many active and retire national level athletes were associated. For Taiwan, adding sport universities/departments where most national level athletes were currently registered. A "Participant's Envelop" was prepared for each potential targeted or non-specified participant on the recruiting list. Every envelop contains: 1. Risk-IQ - German or Traditional Chinese (TC) version questionnaire 2. Recruiting flyer (German or TC) 3. Return mailing address and postage. For team coaches or organizational leaders, an official letter of intent was also included. Personal contact through phone, electronic and email communication were also adapted for follow-up.

MCP project

The recruiting process for MCP project started from mid-October, 2013 for German participants and Early December, 2013 for Taiwan till May 2014 for both sides. Targeted organizations including: Medical division of Olympic sport training centres of both countries, team physician of nationals (Olympic) sport delegations. For Germany, adding national medical association and DOSB certified regional medical centers. For Taiwan, adding sport medicine specialized hospital and clinics where most of the first line medical staff for elite athlete were employed. A "Participant's Envelop" was prepared for each potential or non-specified participant. Every envelop contains: 1. MCP questionnaire (German or TC version) 2. Recruiting flyer (German or TC) 3. Return mailing address and postage. An official letter of intent was also included for director/head of the targeted organization. Personal contact through phone, electronic and email communication were also used for follow-up.

4.4 Study Phases, Participants and Cohorts

Pre-test and Pilot Study

The German draft of the Risk-IQ questionnaire was developed based on the IOC consensus statement, training environment and stress related instruments. A pilot test was conducted (Figure 6) to ask the participants whether any sentences were difficult to understand. Questionable items or wordings were recorded and reported to the questionnaire development committee for further discussion and revision. Original German draft version of Risk-IQ was revised before given to translators for forward and backward translation. The questionnaire's instructions, items and responses were first translated into Chinese (Traditional) by two independent native Chinese speakers with excellent knowledge of German. After translation we conducted the test-retest study in which the participants completed the questionnaire twice within an interval of 7-10 days. In this study, only quantitative data are used for test retest reliability analysis of the questionnaires.

Official Surveys

After returned questionnaires of both Risk-IQ and MCP projects all collected, contents of answers were inspected before keyed into databases. A total of seven Risk-IQ returned questionnaires were excluded from further analysis (Figure 6). Three of MCP participants were rejected for similar reasons. Coding sheets which contain variables detail specified information were prepared before statistical analysis.

4.5 Data Process

Both sets of raw data of Risk-IQ and MCP questionnaires collected from Germany and Taiwan were coded with a serial numbers consist of receiving date, gender, age and sport type information before processed into a spreadsheet for further formatting for various scales/sub-scales scores calculation and statistical analysis. A coding sheet was created with all variables descriptive and characteristic information designed particularly for statistical soft ware data entry process and analysis. Dummy variables were created and recoded for dichotomise/binary answers for regression tests.

4.6 Statistical Analysis

In preliminary stage of this study project, descriptive analysis and odds ratios information for injury risk related variables as well as predictor variables for best-fit modelling which performed through combination of logistic regression and multiple regressions (Wang 2015). However, due to different focuses of three published articles in this thesis, detailed statistical analysis methods employed in each article described in its own statistical analysis sections. All statistical analyses were carried out using SPSS 22.0 (IBM SPSS Statistics 22, IBM, USA).

Pilot Study

In the pre-test and pilot study, besides descriptive statistics, different statistical analyses were employed for various tasks. Intraclass-correlation-coefficient (ICC) and Spearman correlation coefficient (ρ) for non-parametric tests were performed. Reliability alpha adapted for Test-retest reliability. Factor analysis and Cronbach's alpha tested for internal consistency and construct validity of newly constructed scale. Bland and Altman Plot with limits of agreement adapted for translation reliability tests.

Official Surveys

Descriptive statistics were performed using mean, SD and 95% confidence interval (CI). Spearman correlation coefficients (ρ) were used for nonparametric data. The significance level was set at $p < 0.05$. For multiple sport groups comparisons between German and Taiwan. For non-parametric independent variables (2 groups) comparisons Mann-Whitney U test and Kruskal-Wallis test were performed for non-parametrical independent variables comparing more than 2 groups.

5. STUDIES

5.1 Study 1

TRANSLATION RELIABILITY AND TEST-RETEST RELIABILITY FOR ELITE ATHLETE'S INJURY RISK FACTOR QUESTIONNAIRE

Victor C. Wang¹, Frank Mayer¹, Fabian Ottawa², Pia M. Wippert²

¹ Department of Sport Medicine and Sport Orthopaedics, University Potsdam, Potsdam 14469, Germany

² Department of Sociology of Physical Activity and Health, University Potsdam, Potsdam 14469, Germany

Reference

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5.1.1 Abstract

The aims of this study were: 1. to develop an elite athlete's injury risk factor questionnaire (Risk-IQ) and to investigate its reliability in a pilot study. 2. to analyze translation reliability and construct validity of the Risk-IQ for two languages. 3. to assess test-retest reliability of the Risk-IQ. The first draft of the pilot study started with a draft Risk-IQ only on German sport students ($n = 46$). Next, the four hundred and six items of the Risk-IQ were translated by four bilingual German/Chinese (Taiwan) professional translators in an 8-step forward-backward translation, and then tested for the following translation and test-retest reliability. The reliability results were assessed with college level sport students ($n = 63$) before the main study for German and Taiwanese elite athletes ($n = 335$). Descriptive statistics, Intraclass-correlation-coefficient (ICC) and Spearman correlation coefficient (ρ) for non-parametric tests were performed. Cronbach's alpha and Factor analysis evaluated for internal consistency and construct validity. The results indicated that the main outcomes derived from translation reliability and test-retest study were ICC: difficulty-forward= 0.82, difficulty-backward= 0.75; quality-(concept)-forward = 0.74, quality-(concept)-backward = 0.73; quality-(clarity)-forward = 0.76, quality-(clarity) - backward = 0.70; quality-(linguistics)-forward = 0.71, quality-(linguistics)-backward = 0.59. A correlation coefficient of 0.97 was reached in bidirectional-translations. Leading to a combined forward-backward translation reliability correlation coefficient = 0.86. The results further showed that test-retest reliability of both German and Chinese versions were of moderate to excellent levels (German- $\rho = 0.70- 0.94$; Taiwan- $\rho = 0.68- 0.92$). In addition, good internal consistency in the Risk-IQ main study was found with Cronbach's alpha ranging from 0.76 to 0.96. These findings conclude that Risk-IQ's German-Chinese bilingual, bi-directional translation reliability, test-retest reliability and construct validity reached "good" to "excellent" level.

5.1.2 Introduction

Sport injury is often the most devastating setback for elite athletes competing at international level. The severity of injury may cause the athlete to miss the competition, lose a chance to podium, or even to end his or her sport career. Due to the prevalence of injury and complexity of sport injury risk factors, the research of injury prevention and risk factor identification has been an international common focus of publication for decades (Anderson & Williams, 1988; Corrado, Basso, Schiavon, Pelliccia, & Thiene, 2008; Engebretsen & Bahr, 2009). Between 1980 and 2004 Olympic Games, various international sport communities and the International Olympic Committee (IOC) have tried to monitor injury incidences and collect data from major competitions (Junge, Dvorak, Graf-Baumann, & Peterson, 2004; Meeuwisse & Love, 1998) setting the foundation for the standardized overall injury surveillance program at the Summer and Winter Olympic Games which started in 2008 (Engebretsen et al., 2013; Junge et al., 2008). Furthermore the IOC published a consensus statement in 2009 for health promotion and injury prevention as recommendation criteria for international sport authorities and sport medicine professionals (Ljungqvist et al., 2009). However, there are no standardized instruments for the evaluation of these recommended criteria. There are no established criteria available for athletes' Periodic Health Examination (PHE) and Pre-Participation Evaluation (PPE). This research study aims to close this gap by developing and proofing a functionally and linguistically valid evaluation tool to be used in different countries.

In-depth studies investigating the injury risk factors of elite athletes mostly focused on single causes of injury although the injuries are often multi-factorial (Bahr & Holme, 2003). Literature of injury/illness related risk factors for elite athletes showed that only cardiovascular risk factor screening involved a wide spectrum of factors (Thünenkötter, Schmied, Dvorak, & Kindermann, 2010). Various groups of sport scientists have investigated the psychological characteristics as well as social environment as risk factors for elite athlete injury (Anderson & Williams, 1988; Steffen, Pensgaard, & Bahr, 2009; Wiese-Bjornstal, Smith, Shaffer, & Morrey, 1998). However, a multi-disciplinary integrated comprehensive evaluation instrument for investigation of injury risk factor is not yet available. Therefore, the relationship between the different risk factors and their effects are not yet completely understood.

The development of such instrument requires an in-depth knowledge of the heterogeneous international elite sport system structures, which is perhaps found few precedents in the literature. One existing instrument is the Colorado Injury Report System (CIRS, Hanson, McCullagh, & Tonymon, 1992; Perna & McDowell, 1995), a standardized questionnaire for severe injury evalua-

tion. However this instrument has not been used for the evaluation and monitoring of the injury risk factors or the risk score of an athlete.

The standardization process for a new questionnaire requires factor analysis of included items and scales and test-retest reliability evaluation. Translation reliability test also necessary, if any another culture or language is involved (Beaton, Bombardier, Guillemin, & Ferraz, 2002; Bullinger, 1995). Cross-cultural relevance must also be considered when developing the questionnaire. Translating of an instrument procedure simply from one language word-to-word into another language is inadequate to account for linguistic and cultural differences. Four elements, including content, semantic, technical and conceptual should be considered in order to reach the highest level of reliability in cross-cultural translation (Lee, Li, Arai, & Puntillo, 2009). In addition, when measures are to be used in different languages, the items of the evaluation tool must not only be translated well linguistically, but also culturally adapted to maintain the content validity of the instrument at a conceptual level across different cultures (Harkness, Pennell, & Schoua-Glusberg, 2004). Theories and methods on evaluating the reliability of translation have been developed and adapted for different research contents and goals. Brislin (1970) suggests a “backward and forward” translation process for instrument to be used in cross-cultural research. Furthermore, McDermott, and Palchanes (1994) recommended that at least two independent bilingual translators should perform the translation.

The aims of our study were: 1. to develop an elite athlete’s injury risk factor questionnaire (Risk-IQ) which was based on the PHE and PPE criteria described in the IOC consensus statement and investigate its reliability in a pilot study. 2. to analyze Risk-IQ’s construct validity and its translation reliability between two different languages (German and Traditional Chinese/TC) in a test-retest study. 3. to assess the test retest reliability of Risk-IQ for German and Taiwanese athletes in a main study in which we evaluated the risk potential of Olympic athletes.

5.1.3 Materials and methods

5.1.3.1 Participants

5.1.3.1.1 Pilot study

In the pilot study, 46 German native speaking sport students (27 female, 19 male, age 26 ± 6.7 yrs.) were included and gave feedback on the quality and comprehensibility of the questions themselves and the overall structure of the Risk-IQ.

5.1.3.1.2 Test-retest study

After the translation process, the Risk-IQ was tested in two cohorts of German and Taiwanese sport students ($n = 35$ Germans, 19 female, 16 male, age 21.5 ± 3.5 and $n = 28$ Taiwanese, 3 female, 25 male, age 23 ± 2.8). The students were recruited from the Sport Science Department of the University of Potsdam and the National Taiwan Sport University respectively. Inclusion criteria was a physical activity level of 2-4 sessions per week of sport related activities with 2-3 hours per session

5.1.3.1.3 Main study

In the main study, 269 Taiwanese elite athletes (121 female, age = 22.7 ± 5.6 ; 148 male, age = 23.6 ± 7.8) and 66 German athletes (32 female, age = 24.0 ± 5.9 ; 34 male, age = 27.9 ± 7.8) recruited from national training centers and institutes participated. Inclusion criteria were current or retired national team members of Olympic sport events who trained for international competition.

5.1.3.2 Instrument—Risk-IQ

The elite athlete's injury risk factor questionnaire (Risk-IQ) is a multi-disciplinary and self-rated evaluation tool developed for the evaluation of the injury related risk of elite athletes during preparation for the major international games. The Risk-IQ consists of six main elements which are:

5.1.3.2.1 Demography

The "Demography" section covers basic personal and sport related background information which consisted of 14 items (e.g. "gender", "age", "sport type", "international competition experiences", "most career-influential sport event").

5.1.3.2.2 Medical history

The "Medical History" section deals with personal and family related medical histories. Questions from existing evaluation measures of the IOC-Consensus Statement 2009 were adapted and adopted. In addition, for a comparison of the new developed Risk-IQ the athletes also were asked to complete the Colorado Injury Reporting System (CIRS) in this section.

5.1.3.2.3 Pre-participation evaluation-PPE

The PPE was adapted from the IOC-Consensus Statement 2009, predominately conducted on

nominal data base (therefore dummy variable was created for analysis), and separated into different sections namely Overall history, Cardiovascular Musculoskeletal-Head & Neck and Injury & Days Missed. The *Overall history* consisted of 15 items, example “When was the last time you had a comprehensive physical/health examination? 1 = within 1 yr., 2 = 1-2 yrs., 3 = 2-3 yrs., 4 = 3-4 yrs. 5 = 4 yrs. and longer, 6 = cannot remember anymore. The *Cardiovascular* section contains 9 items, example “Have you ever had any one the following circulation related problem: Chest pain, discomfort, tightness or pressure with exercise? 1 = Yes, 2 = No”. The *Musculoskeletal-Head & Neck* section comprised of 13 items with an example of “Have you ever had injuries to the face, head or brain (concussion or headache after impact) before participation of sport training? 1 = Yes, 2 = No”); and *Injury & Days Missed* included 3 items, example “Have you ever missed an international competition due to injury? 1 = Yes, 2 = No”.

5.1.3.2.4 Periodical health evaluation-PHE

Modified from the IOC-Consensus Statement 2009, the PHE consists on nominal scales (dummy variable created for analysis in the case of ordinal items) that were separated into five sections, namely *Medical Care Examination* (6 items, e.g. “How important do you rate the musculoskeletal risk factor screening for your prevention of sport injury?” 1 = very important; 2 = important; 3 = no opinion, 4 = not important; 5 = totally not important), *Physical Examination* (9 items, e.g. “During your training period, have you ever had a physical examination on the following body parts: Shoulder/Upper Arm? 1 = Yes, 2 = No”), *Medical Treatment* (13 items, e.g. “During your training period, have you ever had one of the following treatments: Cortisol injection? 1 = Yes, 2 = No”), *Medical Care Quality* (5 items, e.g. “Do your religious beliefs influence your medical treatment choice? 1 = Yes; 2 = No”) and *Health & Consumption Behavior* (4 items, e.g. “Do you sometimes take medically prescribed medication? 1 = Yes; 2 = No”).

5.1.3.2.5 Environment & training

The section “Environmental and Training” was based on theoretical knowledge and represents typical pronounced high environmental risk factors. For this section the Risk-IQ, Likert type scale development and exploratory factor analysis (EFA) were conducted (Petrowski, Paul, Albani & Brähler, 2012). This consists of a series of 13 items in 3 sections, namely *Environment* (7 items, Cronbach’s alpha = 0.89; e.g. “Please select one of the descriptions to best fit the condition of your [indoor/outdoor) training environment 1 = very bad, 2 = bad, 3 = no opinion, 4 = good, 5 = very good”), *Training* (4 items, Cronbach’s alpha = 0.87; e.g. “Do you think there is a correlation

between the training facility/equipment and your injury? 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly disagree) and *Risk and Injury* (2 items, Cronbach's alpha = 0.74; e.g. "Do you think you are exposed to extreme weather conditions during your training?" 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly disagree). Factor analysis of the Environment & Training section indicated an internal consistency (Cronbach's alpha) with good to very good reliability and construct validity.

5.1.3.2.6 Stress

Two standardized psychometric tools, including Inventory of Life Event (ILE, Siegrist & Geyer, 2014) and the Perceived Stress Scale (PSS, Cohen, Kamarck, & Mermelstein, 1983) were used to assess the stress. These tools were already adapted and standardized for different languages and cultures. Unfortunately Chinese version was not among the languages available for this tool. Thus, they were not included in the content reliability, but in the translation reliability analysis in this study.

5.1.3.2.7 Colorado Injury Report System (*CIRS*)

CIRS is a standardized scale, first adapted by Blackwell and McCullagh for following injury during athletic training (Blackwell & McCullagh, 1990; Perna & McDowell, 1995). It was used in the Risk-IQ for elite athlete sport training and severe injury reporting. The *CIRS* required athletes to log the injured body parts, injury and treatment types, illness/injury days as well as "return to play" days for serious and influential injury to elite athlete. *CIRS* consist of 12 items with an example of "Severity of injury, 1 = treatment plus no limitation of sport activity; 2 = treatment plus limited sport activity; 3 = 1-7 days restriction from training and competition; 4 = 8-21 days restriction from training and competition; 5 = 21 + days restriction from training and competition".

5.1.3.3 Study procedure

The German draft of the Risk-IQ questionnaire was developed based on the IOC consensus statement, training environment and stress related instruments. A pilot test was conducted by asking the participants, whether any sentences were difficult to understand. Questionable items or poor wordings were recorded and reported to the questionnaire development committee for further discussion and revision. The original German draft version of Risk-IQ was revised before being given to translators for forward and backward translation as described below (Figure 7). The questionnaire's instructions, items and responses were first translated into Chinese (Traditional) by two independent native Chinese speakers with excellent knowledge of German. After translation, we conducted a test-retest study in which the participants were completed the questionnaire twice

within an interval of 7-10 days. In our recent publication, only quantitative data have been presented for the test-retest reliability analysis of the questionnaire (Wang, Ottawa, Mayer, & Wippert, 2014).

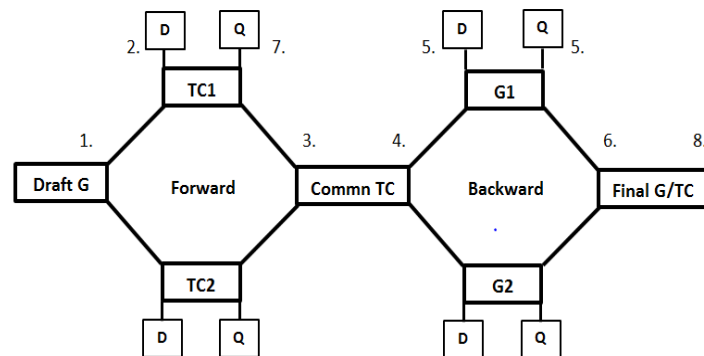


Figure 7. Forward and Backward Translation Procedures

- Step 1 A draft version (German) is provided to 2 native TC translators for forward translation
- Step 2 Both TC translators giving difficulty ratings during forward translation process
- Step 3 TC translators meet and discussed for the common TC version
- Step 4 The common TC version is given to 2 native German translators for backward translation
- Step 5 Difficulty and quality ratings of TC version are given by German translators during backward translation
- Step 6 German translators meet for the common final German version
- Step 7 Quality ratings of common German version are given by two TC translators
- Step 8 Both TC and German final versions are reviewed by the questionnaire developing committee

- D = Difficulty Ratings
- Q = Quality Ratings (Conceptual Equivalence, Clarity, & Linguistic Performance)
- TC = Traditional Chinese
- G = German

5.1.3.4 Translation procedure

A stepwise translation process is recommended to improve the cultural equivalence during cross-cultural translation (Leung, Yen, & Tse, 2004). Therefore, an 8-step forward and backward translation process was utilized for cross-cultural translation of self-reported measures to produce the final Chinese and German versions of the questionnaires (Bullinger, 1995) (Please see footnote of Figure 7). Forward translation was conducted by two bilingual translators of Taiwanese descent, who speak, read and write Traditional Chinese and German fluently. Both translators received graduate-level German literature degrees from Germany. Backward translation was performed by two German native-speaking translators, who received graduate-level Sinology degrees. One of the two German translators is certified in teaching medical German. All translators were informed of the purpose of the study prior to translate.

During the forward and backward translation of the Risk-IQ (for both German and Chinese), a concurrent review and revision of the content was conducted by the questionnaire development committee. Revisions of problematic questions were communicated with all translators involved

for version updating. For example, the wording clarification was used for the term “location” of injury (“Ort” der Verletzung) in section II.-CIRS of the German questionnaire where participants stated which body part was the subject to injury. Instead, the term “injured body part” (“Verletztes Körperteil”) was used in this study. In the final stage, the questionnaire development committee finalized both versions of the Risk-IQ before commencing the test-retest study.

5.1.3.5 Difficulty and quality ratings

During forward translation, the difficulty ratings for the German draft were given by two Chinese native-speaking translators on the instructional paragraphs, items and response choices on a scale from 0 to 10 (lowest to highest level of difficulty) in increments of 0.5. Likewise, in backward translation, the difficulty and quality ratings of the traditional Chinese draft were evaluated by two German native-speaking translators using the same rating system. The quality ratings for the final German version were given by two Chinese translators afterward. The quality of translations in both forward and backward translation were rated in terms of conceptual equivalence (are the original concepts reflected in the translation?), clarity (is it brief and straightforward?) and linguistic performance (does the translation involve common language?). All items ($n = 406$) from all sections (including titles and sectional instructions) of the Risk-IQ were translated bi-directionally by all 4 translators and analyzed for reliability. Copies of the forward and backward translations as well as all ratings of the final versions were then sent to the questionnaire development committee for further translation reliability analysis of both German and Chinese (Taiwan) versions of the Risk-IQ.

5.1.3.6 Statistical analysis

Descriptive statistics were performed using mean, SD and 95% confidence interval (CI). Intraclass correlation coefficient (ICC 2.1) was calculated for reliability. Limits of agreement between forward and backward translation were determined through Bland and Altman analysis (Bland & Altman 1999). Spearman correlation coefficients (ρ) were used for nonparametric data and Cronbach alpha for the internal consistency and construct validity. The significance level was set at $p < 0.05$. All statistical analyses were carried out using SPSS 21.0 (SPSS Statistics 21, IBM, USA).

5.1.4 Results

5.1.4.1 Validity and reliability

Validity of questionnaire: ICC values of translation reliability for all 4 rating scales regarding the overall questionnaire were as follows (Table 4) : difficulty rating -forward ICC = 0.82, -backward ICC = 0.75; quality rating (conceptual equivalence) -forward ICC = 0.74, -backward ICC = 0.73; quality rating (clarity) -forward ICC = 0.76, -backward ICC = 0.70; quality rating (linguistic performance) -forward ICC = 0.71, -backward ICC = 0.59 (all values $p < 0.05$).

Inter-rater reliability for 3 rating groups in 2 translation directions was calculated for ICC and data presented in Table 5. Forward translation had higher correlation coefficients in both difficulty rating (ICC = 0.90) and quality rating (ICC = 0.82) compared to the backward translation (difficulty rating ICC = 0.86, quality rating ICC = 0.80). However, an equal correlation coefficient of 0.97 was reached. Overall forward and backward translation reliability with combined raters and rating scores were presented in a Bland and Altman plot (Figure 8). Limits of agreement were indicated as the zone bounded by the two lines of upper limit (= 0.87) and lower limit (= -1.25).

Table 4. Reliability (ICC) of Difficulty & Quality Ratings by Sections

Section	Difficulty		Quality –Concept Equivalency		Quality – Clarity		Quality – Linguistic Performance	
	F	B	F	B	F	B	F	B
Demography	0.96*	0.98*	0.85*	0.79*	0.9*	0.69*	0.89*	0.79*
Medical History	0.81*	0.69*	0.53*	0.68*	0.63*	0.69*	0.54*	0.35*
Pre-participation Examination – PPE	0.91*	0.93*	0.76*	0.75*	0.69*	0.85*	0.53*	0.57*
Periodical Health Examination - PHE	0.65*	0.80*	0.91*	0.85*	0.87*	0.61*	0.86*	0.77*
Environment & Training	0.87*	0.61*	0.57*	0.53*	0.82*	0.70*	0.80*	0.57*
Stress (ILE)	0.71*	0.55*	0.76*	0.78*	0.52*	0.51*	0.63*	0.43*
Stress (PSS)	0.84*	0.67*	0.80*	0.73*	0.88*	0.84*	0.69*	0.63*
Overall Rating	0.82	0.75*	0.74*	0.73*	0.76*	0.70*	0.71*	0.59*

*CI =95% F= Forward B= Backward

Table 5. Reliability(ICC) of Forward-Backward Translation

Inter Rater	Difficulty	Quality	All Ratings	Combined
Forward	0.90	0.82	0.97	0.86
Backward	0.86	0.8	0.97	
CI= 95%	Forward = German -> Traditional Chinese, Backward = Traditional Chinese -> German			

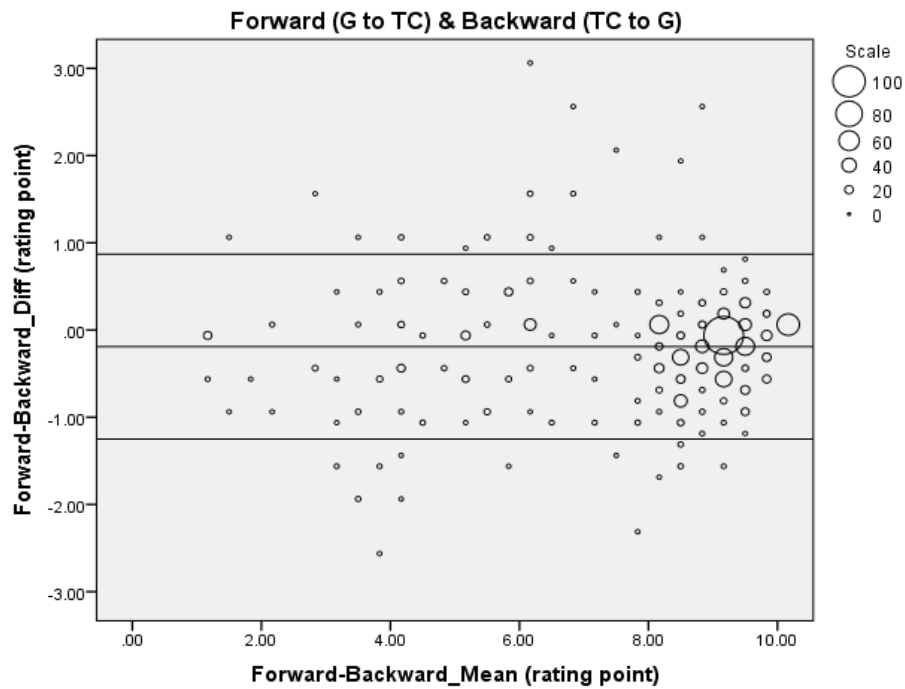


Figure 8. Bland and Altman Plot of forward and backward translation reliability
Combined ratings (averaged) and translators

5.1.4.2 Test-retest study

Reliability of questionnaire: Test–retest reliability, as defined by Spearman’s rho, showed "excellent to moderate" reliability in all sections of the German questionnaire. In detail, Pre-participation Examination -PPE rho = 0.90 ($p < 0.05$); Medical History rho = 0.89 ($p < 0.05$) and Environment & Training rho = 0.80 ($p < 0.05$). Periodical Health Evaluation -PHE rho = 0.78 ($p < .05$) and CIRS rho = 0.70 ($p < .05$).

The results from the Chinese (Taiwan) version showed that most sections were in “excellent to moderate” levels: Environment and Training rho = 0.92 ($p < .05$); Medical History rho = 0.84 (p

< .05); Periodical Health Examination-PHE ($\rho = .72$, $p < .05$) and section. Pre-participation Examination -PPE $\rho = 0.78$ ($p < .05$). Only the CIRS section ρ -values were < 0.70 as observed (Table 6).

Table 6. Test-retest Reliability (Spearman ρ) for pilot Risk-IQ

Section Tested	German	Taiwan
Medical History	0.89*	0.84*
CIRS	0.70	0.68
<i>Pre-participation Examination —PPE</i>	0.90*	0.78*
<i>Periodical Health Evaluation – PHE</i>	0.78*	0.72*
Environment & Training	0.80*	0.92*

* $p < 0.05$

5.1.4.3 Main study

The results of final Risk-IQ questionnaire are now in the validation process, surveying over 335 German and Taiwanese elite level athletes. The construct validity and internal consistency test of the final Risk-IQ survey showed Cronbach's alpha values throughout all sections lying in a range from 0.757 (appropriate) to 0.961(excellent) levels (Wang, Mayer, & Wippert, 2015).

5.1.5 Discussion

In response to our first hypothesis the findings indicated that due to the less culturally sensitive nature of medical and sport training terms adapted in the Risk-IQ particularly in PPE, PHE and Environmental and Training sections, the questionnaire has a reasonably good to excellent level of test retest reliability. The test-retest ρ values from the results of all Risk-IQ sections fall in the “strong” (0.70 to 0.89) or “very strong” (0.90 to 1.00) correlation ranges, which represent “good to excellent” reliability. The only exception appeared in the CIRS section ($\rho = 0.68$) of the Traditional Chinese (Taiwan) version, which would fall into the “moderate” correlation range. One possible explanation for this could be that the answers were “subject- dependent”, only subjects who had severe injuries were required to answer the CIRS. Therefore, lower reported rates in both test-retest study (non-elite athlete subjects, 28%) and main study (elite athlete subjects 35.5%), resulted a reduced sample size and reduced reliability.

Secondly, ICC on the questionnaire translation process between German and Traditional Chinese

(Taiwan) was good to excellent. The majority of rating scores were concentrated between a score of 8 and 10, while the majority of differences between forward and backward combined rating scores (782 out of 812 combined ratings, 96.3%) were fall within the limits of agreement (± 1.96 SD; CI = 95%), only 3.7% (30 out of 812) ratings showed differences exceeding the limits of agreement. Two characteristics of the Bland and Altman Plot were examined. First it was discern whether the mean of the differences was significantly different from zero. Indicated by a p -value of 0.5, we determined that the mean of differences was not significantly different from zero. The second test was to assess whether there was any kind of bias between means and differences of the translation ratings, Here, a p -value < 0.005 , indicating a relationship the means and differences was ascertained with the greater mean values go along with greater differences. This finding could simply be caused by the larger sample size. The overall combined (ratings and translators averaged) forward and backward translation reliability correlation coefficient correspondent to Figure 2, ICC is 0.86. According to Fleiss (1986) and Cacchio et al. (2012), the ICC values > 0.75 are considered excellent, 0.75-0.40 as good to moderate and < 0.40 as poor reliability in translation reliability with cross-cultural adaption.

The main limitations of this study are the small sample sizes tested for both the pilot and the test-retest study, For further validation, a larger sample is necessary. Other limiting factors included the international coordination and communication. Yet, in general, the development of a German and a Chinese version of an elite athlete injury risk factor questionnaire (Risk-IQ) were successful in the translation process.

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5.2 Study 2

INJURY RISK FACTOR ANALYSIS OF ELITE ATHLETES IN TRAINING ENVIRONMENT – A COMPARATIVE SURVEY BETWEEN GERMANY AND TAIWAN

Victor C. Wang¹, Frank Mayer¹, Pia M. Wippert²

¹ Department of Sport Medicine and Sport Orthopaedics, University Potsdam, Potsdam 14469, Germany

² Department of Sociology of Physical Activity and Health, University Potsdam, Potsdam 14469, Germany

Reference

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5.2.1 Abstract

Aim: Injury can be a devastating setback for elite athletes whereby injury prevention plays a key role in the biography of athletes. Three aims of the study: 1. to compare if there are differences between German and Taiwan elite athletes in injury related factors. 2. To evaluate the influence of these factors to injury frequency and 3. To identify possible interactions within injury related factors and the injury risk for both cohorts. **Methods:** $n=335$ elite athletes (269 Taiwanese; 121♀, 148♂, age= 23.2 ± 6.9 ; 66 German; 32♀, 34♂, age= 26.0 ± 7.6) participated. Inclusion criteria: current or retired national team members of Olympic sports. A risk of injury questionnaire (Risk-IQ) for elite athletes was used. Scores were calculated for individual scales/subscales for analysis. Descriptive statistics, independent sample t-tests, Spearman correlation, Mann-Whitney U and Kruskal-Wallis ANOVA tests were employed. Generalized linear models for multivariate regression of scales/subscales were used, significance level $p<0.05$. **Results:** Hypothesis-1: the results of medical care, environment, training, stress, and injury caused losses factors tested significantly different (all $p<.05$) between German and Taiwanese cohorts. Hypothesis-2: regardless of nationality, the injury contributing factors were: age, sport types, experience levels, medical care, cardiovascular problem, training and stress (all $p<.05$). Hypothesis-3: The interaction effect existed between sport type_format, injury caused losses and medical care support. **Conclusion:** injury related influencing factors and interactions can be found via multi-disciplines integrated Risk-IQ regardless of heterogeneous recruitment. Top-5 injury risk factors were: 1. Experience Level (international competition); 2. Number of PHE & PPE received; 3. Sport Types; 4. Stress from life event; 5. Age.

5.2.2 Introduction

Health is the indispensable pre-condition for sporting excellence. However, injury and illness, regardless of acute or chronic, can be the most devastating setbacks for elite athletes competing at the international level. Poor health often causes the athlete to miss competition, lose a chance to podium, or even end his or her sport career. As format of sport events evolve gradually, so does the focus of sport injuries and the complexity of the associated risk factors, both of which have generated great interest leading to research of injury prevention and risk factor identification over time (Andersen & Williams 1988, Engebretsen & Bahr 2009, Corrado, Basso, Schiavon, Pelliccia & Thiene 2008).

Between the 1980 and 2004 Olympic Games, various international sport organizations such as FIFA and IOC have tried to monitor injury incidences and collect data from major competitions (Junge, Dvorak, Graf-Baumann & Peterson 2004, Meeuwisse & Love 1998) which set the foundation for the injury surveillance program of the Summer and Winter Olympic Games since 2008 (Engebretsen et al. 2012, Junge et al. 2008). The International Olympic Committee published a consensus statement in 2009 for health promotion and injury prevention as recommendation criteria for international sport authorities and sport medicine professionals (Ljungqvist et al. 2009). This expert supported consensus statement contained two main domains: cardiovascular and orthopaedic aspects of sport medicine, and the protocols were organized in two focuses: Periodic Health Examination (PHE) and Pre-Participation Evaluation (PPE). However, the standardized instruments for these recommended criteria are not available for athletes' PHE and PPE up to date (Wang 2015).

Risk factors of elite athletes' injuries are often multi-factorial and cover a full spectrum of different aspects of one's lifespan as Bahr and Holme suggested (Bahr & Holme 2003). In the past, research on the topic of injury risk factor identification mostly focused on single causes of injury or within non-elite athlete cohorts. Many investigations have been conducted by various groups of sport scientists over years to analyse psychological characteristics as well as social environment as risk factors for injuries amongst elite athletes (Anderson & Williams 1988, Steffen, Pensgaard & Bahr 2009, Wiese-Bjornstal, Smith, Shaffer & Morrey 1998). Psycho-sociological theory, such as the *Inventory of Life Event (ILE)*, has been proved by many studies to be highly relevant to incidence of injury (Siegrist & Geyer 2014).

Nevertheless, studies of environmental factors, such as training and environmental conditions related to injury risk, are lacking the use of standardized scales. This is the reason why it is already

a taunting task to integrate all possible factors together in a comprehensive model as suggested by Andersen and Williams (1988).

The present study is an attempt to close this gap of knowledge and to deal with this task using a comprehensive instrument evaluating risk factors and medical care to better understand the relationship between risk factors and their associated effects. The aims (hypotheses) of the present paper are 1. To compare the differences between German and Taiwanese elite athletes, regarding injury related factors such as medical, psychosocial and training environment. 2. To evaluate the influence of injury related factors to injury frequency and 3. To identify possible interactions within these factors and the injury risk factors for both cohorts.

5.2.3 Materials and methods

5.2.3.1 Participants

Three hundred and thirty-five elite athletes [$n=269$ Taiwanese; 121 female (22.65 ± 5.6 yrs.), 148 male (23.57 ± 7.8 yrs.) and $n=66$ German athletes; 32 female (23.97 ± 5.6 yrs.), 34 male (27.94 ± 7.8 yrs.)] were recruited from national training centers and institutes for the study. Inclusion criteria were current or retired national team members of Olympic sports who trained for international competition. The distributions of gender, physical activeness and training status among the participants (German and Taiwanese) were homogenous (all $p > .05$). Only age was significantly different between the groups (Taiwan and German, $p < 0.01$).

5.2.3.2 Study procedure

For this cross-sectional study elite athletes were recruited by letter via post. Contact information was obtained through nationwide databases of sport training centers, sport universities and sport federation networks in both Germany and Taiwan. An individual package consisted of invitational letter, explanatory note/flyer, questionnaire, return envelope with address and postage was provided for each participant. Each participant's answered questionnaire was sealed individually and data was treated anonymously, following privacy protection protocol.

5.2.3.3 Instruments – elite athlete's risk of injury questionnaire (Risk-IQ)

The Risk-IQ is an interdisciplinary, linguistically and culturally validated questionnaire with a "good To excellent" overall combined forward and backward translation reliability correlation coefficient ($ICC = .86$). The Risk-IQ also shows good to excellent test-retest reliability (German version Spearman $\rho = 0.70-0.94$, Taiwanese version $\rho = 0.68-0.92$, see also Wang, Mayer, Ottawa & Wippert

2015). For the present study six parts of the Risk-IQ were used, such as the *Medical History*, the *Pre-participation Evaluation*, *Periodical Health Evaluation*, the *Health & Consumption Behaviour*, the *Environment & Training Condition* as well as the *ILE* and the *Perceived Stress Scale (PSS)*.

Medical History: The medical history section of the Risk-IQ contained five subscales for personal and family related medical history, namely: I. *Injury Frequency* scale which consisted of 68 items from 11 types of injuries (e.g. “muscle strained”; “bone fracture”; “over-used injury”; and “others”) in 10 body parts (e.g. “upper and lower back”; “knee”; “leg & ankle”), whereby frequencies of each injury were required to be specified (Cronbach’s $\alpha=.86$). The total count of all injury occurrences amongst the 10 body parts was calculated as the score. II. *Overall History* subscale consisted of 15 items (e.g. “When was the last time you had a comprehensive physical/health examination? 1=within 1 yr., 2=1-2 yrs., 3=2-3 yrs., 4=3-4 yrs. 5=4 yrs. and longer, 6=cannot remember anymore) with a Cronbach’s α in the sample of = .66. The scale was scored in numerical values. III. *Cardio-vascular Problem* subscale, consisted of 9 items, (e.g. “Have you ever had any one the following circulation related problem (Chest pain, discomfort, tightness or pressure with exercise? 1=Yes, 0=No”, Cronbach’s $\alpha= .71$)). IV. *Musculoskeletal, Head & Neck Injury* subscale, contained 13 items, (3 items of head and neck injury incident experience converted into frequency plus 10 items from ten body parts subtotal) (e.g. “Have you ever had injuries to face, head or brain (concussion or headache after impact) before participation of sport training?) 1=Yes, 0=No”), Cronbach’s $\alpha= .83$. V. *Injury Caused Losses* subscale, consisted of 2 items (e.g. “Have you ever lost a chance for medal due to injury in international competition?” 1=Yes, 0=No, Cronbach’s $\alpha= .85$). For the last three scales (III, IV, V) the total of “Yes” responses from all items represent the total score.

Pre-participation Evaluation (PPE) & Periodical Health Evaluation (PHE): Based on the IOC consensus statement and related documents the PPE & PHE scale of the Risk-IQ contained four subscales, namely: I. *Medical Care Exam* subscale which consisted 6 items (e.g. “How important do you think the musculoskeletal risk factor screening for your prevention of sport injury?” 1 = very important; 2 = important; 3 = no opinion, 4 = not important; 5 = totally not important”) with a Cronbach’s $\alpha= .76$. II. *Physical Check-up* subscale, which consisted 9 items (e.g. “During your training period, have you ever had a physical examination on the following body parts: Shoulder/Upper Arm? 1=Yes, 0=No”, Cronbach’s $\alpha= .99$). III. *Medical Treatment* subscale which consisted of 13 items (e.g. “During your training period, have you ever had a following treatment: Cortisol injection? 1=Yes, 0=No”, Cronbach’s $\alpha= .90$). IV. *Medical Care Support (Variety & Frequency)* subscale, consisted of 7

items (e.g. “During your training, how often did you receive medical care support service of the following kind: a. Physiotherapist: 1= daily, 2= weekly, 3=monthly“, Cronbach’s α = .87). Scale I was scored in numerical values. Total counts of “Yes” responses from all items represented score of both subscales II and subscale III; the scale IV were scored in mean values.

Health & Consumption Behaviour: this part of the Risk-IQ consisted of 4 items of health related consumptive behaviours or habits: 1. Smoking, 2. Alcohol consumption, 3. Drinking frequency (days per week) and 4. Prescribed medication use (e.g. “In a regular week, how many days per week do you drink alcoholic beverages? 1= none, 2= 1 day, 3= 2 days, 4 = 3 days, 5 = 4 days, 6 = 5 days, 7 = 6 days, 8 = 7 days“), Cronbach’s α = .70.

Environment & Training Condition: this Risk-IQ part is separated in three subscales namely I. *Environment* subscale consisted of 7 items, (e.g. “Please select one of the descriptions to best fit the condition of your (indoor/outdoor) training environment. 1=very bad, 2= bad, 3= no opinion, 4= good, 5= very good”; Cronbach’s α = .89. II. *Training* subscale consisted 4 items, (e.g. “Do you think there is an association between the training facility/equipment and your injury? 1=strongly disagree, 2= disagree, 3= no opinion, 4= agree, 5= strongly disagree) with a Cronbach’s α =.87. III. *Self-identified Risk Factor* subscale consisted of 2 items, (e.g. “Do you think you are exposed to extreme weather condition during your training?” 1=strongly disagree, 2= disagree, 3= no opinion, 4= agree, 5= strongly disagree) with a Cronbach’s α = .74. The scales were scored in mean values.

Inventory of Life Event (ILE) scale & Perceived Stress scale (PSS): these two standardized stress tests are integrated in the Risk-IQ. Both tests are well constructed standardized psychometric tools already adapted for different languages and cultures. The *ILE* (Siegrist & Geyer 2014) consisted of 10 items measured by 40 stressful life event related questions with Likert scale (e.g. 1=strongly disagree, 2= disagree, 3= no opinion, 4= agree, 5= strongly disagree) and reached a Cronbach's α of .73 in the sample. The *PSS* (Cohen Kamarck & Mermelstein 1983) consisted of 10 items with responses on a 5-point Likert scale from 0 (= never) to 4 (=very often) and was referenced to the past 12 months (e.g., “In the last 12 months, how often have you been upset because of something that happened unexpectedly?”). The sum of the answers gave information about the corresponding stress value. The α in the tested samples was .73

Due to the imbalanced numbers of different sport type athletes' participation there were furthermore two sport categorizations introduced namely: "Sport Type_format" with 5 groups: individual-non-contact (e.g. Archery), team-non-contact (e.g. Volleyball), team-contact (e.g. Handball), individual-combat (e.g. Boxing) and team-combat (e.g. Rugby); "Sport Type_location" with 5 groups: on-land without locomotion (e.g. Weightlifting), on land with locomotion (e.g. Cycling), in/on-water (e.g. Swimming), on-snow (e.g. Alpine Skiing), on ice(e.g. Speed Skating). The integration of these variables provided a more robust statistical analysis.

5.2.3.4 Statistical analyses

For both hypothesis 1 and hypothesis 2, descriptive statistics were performed with mean, SD and 95% confidence interval (CI). Mann-Whitney U tests were performed for 2-group comparisons, and Kruskal-Wallis 1-way ANOVA test was performed for comparisons with more than 2 groups. Spearman correlation coefficients (*rho*) were employed for nonparametric data. Significance level was set at $p < 0.05$. For hypothesis 3, logistic regression and multiple regressions were used for the injury related risk factor analysis. Generalized linear models were adapted for multiple regressions. Independent sample *t*-test was used for scale mean-score comparison. All statistical analyses were carried out using SPSS 22.0 (IBM SPSS Statistics 22, IBM, USA).

5.2.4 Results

5.2.4.1 First hypothesis

Regarding the first hypothesis, it can be summarized that there were significant differences of experience levels between the German and Taiwanese elite athlete cohorts. The German athletes were shown to be more experienced. In detail, the cohorts differed significantly in "Summer Olympic Games" (German: $M = 1.77 \pm 0.95$; Taiwanese: $M = 1.60 \pm 1.0$, $p < 0.05$), "World Championships" (German $M = 4.09 \pm 3.53$; Taiwanese $M = 2.58 \pm 3.06$, $p < 0.01$) and "Total International Competitions Experience" ($p < 0.01$) as well as in the "Number of total preparation days" before last major international competition (German = 470 ± 336 days; Taiwanese = 340 ± 406 days, $p < 0.05$). The cohorts also differed within three classifications of sport types including original Olympic sport types, sport type_format and sport type_location. In summary, Taiwan's athletes were more involved in individual sports, non- contact sports, and sports performed on land. Beside differences in sport type and experience level, it was also assumed that further injury related factors (such as the training environment and the psychosocial factor stress) was different in the Taiwanese and German cohort. Independent sample *t*-test results showed that the subscale *Medical Care*

Support (Variety & Frequency) scored three times higher in the German cohort than their Taiwanese counterparts ($M=0.39\pm0.27$; $M=0.11\pm0.15$, $t=19.82$, $p=.011$). Within the subscale *Environment*, the German cohort scored 4.03 ± 0.51 , which was higher than Taiwanese athletes 3.48 ± 0.68 ($t=17.95$, $p=.008$). For subscale *Training*, which describes the influence of training surroundings on injuries, the German cohort scored 1.57 ± 0.7 , being significantly lower than Taiwan cohort (3.59 ± 0.8 , $t=-9.41$ $p=.000$). The German cohort experienced more life events and had an ILE score of 5.44 ± 3.35 , while the Taiwanese cohort scored 3.86 ± 3.91 ($t=8.26$, $p=.010$). Further, the German cohort scored almost three times higher ($M=0.68\pm0.91$; $M=0.24\pm0.49$) than Taiwanese cohort on the subscale *Injury caused losses*. ($t=10.62$, $p=.03$). In summary, in addition to the differences within injury related factors, the German and Taiwanese cohorts also differed significantly in injury frequencies of the 10 body parts. In particular, within the following 6 body regions: head ($t=3.10$), neck ($t=5.61$), back ($t=4.79$), knee ($t=2.04$), leg ($t=1.71$) and foot ($t=2.48$), all $p<.05$).

5.2.4.2 Second hypothesis

For the **second hypothesis** (influence of injury related factors to injury frequency) it is to summarize that the injury frequency was influenced by age ($p=.006$), sport type (sport type_format, $p=.001$, and sport type_location, $p=.004$, Table 7) and experience level ($p<.05$). The results of the Spearman's correlation (Table 8) further supports that the injury frequency was also influenced by the *PHE & PPE total scores* ($\rho=.387$) as well as with subscales of the *PHE & PPE* (e.g. *Medical Care Examination* $\rho=.183$, *Medical Treatment* $\rho=.434$, *Medical Care Support (Variety & Frequency)* $\rho=.356$, *Medical Care Support Speed* ($\rho=.302$), all $p< 0.01$). There were also correlations between the *Injury Frequency* scale and the *Medical History* (subscales *Overall History* $\rho=.418$,

Cardiovascular Problem $\rho=.199$, *Musculoskeletal, Head & Neck Injury* $\rho=.451$, *Injury Caused Losses* $\rho=.423$, all p values < 0.01). Furthermore, a significant correlation was found between injury frequency and life event stress (*ILE* $\rho=.175$, $p < 0.01$).

Multiple regression analysis (stepwise Table 9), of all significantly correlated scales, indicated the result of *Injury Frequency* scale was influenced by the following scales/subscales: *Medical Care Support (Variety & Frequency, and Speed)*, *Medical Care Examination*, *Cardiovascular Problem*, *Injury Caused Losses*, *Muscular Head & Neck Injury* and *Training*. These 7 scales/subscales remained as stable predictors in the generalized linear regression model (after 7 steps, $p<.05$)

Table 7 Result of null hypothesis tests (H_0 : the distribution of *Injury Frequency* scale is the same across categories of independent variables)

Variable	Test conducted	Sig. (p value)
Country	2	0.248
Sex	2	0.707
Age Group	2	0.006*
Sport type	K	0.000*
Sport type_format	K	0.001*
Sport type_location	K	0.004*
When last PHE taken	K	0.026*
Injury caused miss-games	2	0.000*
Injury caused miss-medal	2	0.000*
Importance of cardiovascular screening	2	0.012*
Received PHE during training	2	0.025*
Received PPE before training	2	0.122
Doctor prohibited sport participation	2	0.001*
Medical care support speed	K	0.000*
Physiotherapy_during Training	K	0.977
Physiotherapy_during competition	K	0.118
Medical doctor_during training	K	0.009*
Medical doctor_during competition	K	0.525
Massage_during training	K	0.592
Massage_during competition	K	0.379
Smoking	2	0.519
Alcohol drinking	2	0.183
Days of drinking per week	K	0.758
Take prescribed drug	2	0.468

* level of significance $p < .05$

Table 8 Spearman correlations between *Injury Frequency* scale and other variables

Risk-IQ section	Variable/Scale	Coefficient (rho)	Sig. (2-tailed)	N
<i>Background/Experience</i>	Day Missed_PrepPeriod	.418**	.000	65
	Day Missed_Olympiad	.395**	.000	111
	Nr_Summer Olympic Games Participation	.056	.304	335
	Nr_Winter Olympic Games Participation	.148**	.007	335
	Nr_OG (Summer+Winter) Participation	.139*	.011	335
	Nr_World Championship Participation	.282**	.000	334
	Nr_Intl Championship Participation	.277**	.000	335
	S_Injury Caused Losses	.423**	.000	331
<i>Medical History</i>	S_Overall History	.233**	.000	335
	S_Cardiovascular	.199**	.000	335
	S_Muscular Head & Neck Injury	.451**	.000	335
<i>PPE & PHE</i>	PHE & PPE Total Score	.387**	.000	335
	Medical Care Support_Speed	.302**	.000	277
	Medical Care Support_Importance	-.084	.135	315
	S_Medical Care Exam	.183**	.001	335
	S_Medical Treatment	.434**	.000	335
	S_Medical Care Support(Variety & Freq)	.356**	.000	335
<i>Health & Consumption</i>	S_Health & Consumption Behaviour	-.001	.987	335
	Cigarette smoked per Day	-.050	.385	.387
<i>Environment & Training</i>	S_Environment	.011	.836	333
	S_Training	.052	.348	331
	S_Self-identified Risk Factor	.022	.690	322
<i>Stress (ILE & PPS)</i>	S_ILE	.175**	.004	264
	S_PSS	.058	.554	107

* level of significance $p < .05$

** level of significance $p < .01$

Table 9 Multiple logistic regression of scales in Risk-IQ

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	Regression Coefficient B	Std. Error	Beta		
(Constant)	3.081	8.069		.382	.703
S_Injury Caused Losses	26.109	2.400	.439	10.879	.000**
S_Muscular Head & Neck Injury	1.292	.403	.125	3.206	.001**
S_Medical Care Support_Speed	16.115	3.441	.168	4.684	.000**
S_Training	3.041	.532	.123	5.712	.000**
S_Medical Care Support(Variety & Freq)	9.539	3.039	.073	3.139	.002**
S_Cardiovascular Problem	.574	.226	.052	2.543	.011*
S_Medical Care Examination	4.000	1.416	.100	2.826	.016*

a. Dependent Variable: Injury Frequency (Whole Body Sum) S=scale/subscale

* level of significance $p < .05$ ** level of significance $p < .01$

5.2.4.3 Third hypothesis

In consideration of the **third hypothesis** (identifying possible interactions within injury related factors) the interaction between “sport type_format” and subscale *Injury Caused Losses* was verified to be significant ($p < .01$). Another interaction observed was between “sport type_format” and subscale *Medical Care Support (Variety & Frequency)* which demonstrated a similar pattern of significance ($p < .01$).

In conclusion, the results from the Mann-Whitney U test, Kruskal-Wallis test (hypothesis 1), Spearman correlation test, logistic regression (hypothesis 2) as well as the generalized linear model, the elite athlete’s injury frequency was influenced (but not limited to) the following potential factors: 1. Experience level of international sport competition participation (all different levels were significantly correlated); 2. Number of PHE and PPE received (variety, frequency and speed combined); 3. Sport types (Olympic categorization, as well as format and location); 4. Stress level (*ILE*); 5. Age.

5.2.5 Discussion

The first hypothesis of this study was to compare all injury related variables in Risk-IQ between two cohorts from Germany and Taiwan. The descriptive results presented significant differences

throughout different Risk-IQ parts. The German athletes were older and more experienced. They also had a better training environment, superior medical support and were less involved in individual sports. On the other hand, they showed more injuries, a higher stress exposure, and a longer healing/rehabilitation duration of injuries when compared to their counterparts of Taiwan. In both groups injury related factors appeared, but they were differently distributed. Due to this heterogeneous circumstance the logistic regression was used to review and clarify this country effect in further analysis. With the exception of the higher injury rate in German athletes, differences in medical care and environmental factors, with advantages for German athletes were expected. The identified factors were also in line with the literature about possible risk factors. However, another possible explanation is that age and sport type factors alone, or combined, could also lead to a higher injury frequency in the German cohort, simply due to the possibility that athletes of older age may experience more stressful life events which proved to be correlated to injury.

To gain more knowledge about the influence and importance of different injury risk factors, further analysis (second hypothesis) was conducted. Five factors remained stable, which were considered the best predictors for observing differences between the two cohorts from Germany and Taiwan. The *Injury Caused Losses* subscale result, indicated the German cohort had nearly a 3 fold higher mean score than their Taiwanese counterparts. This finding was consistent with the fact that German elite athletes reported higher frequencies of participation in higher levels of international sport competitions, thus higher exposure rate to injury caused losses (matches and medals). The result of subscale *Medical Care Support (Variety & Frequency)* indicted the German cohort had a 3.5 times higher ratio value than the Taiwanese cohort. This means when considering all 3 types of medical care services (active and passive physiotherapy, as well as physician's medical care) German elite athletes could receive, on daily to monthly basis (variety and frequency combined), 3.5 times more medical care support than their counterparts in Taiwan. The results of *Environment* subscale showed significant difference between the two countries on the athletes' opinions toward their training related environment. Averagely speaking, the German cohort (mean=4.03) considered their overall training environment quite good in comparison to the Taiwanese cohort (mean=3.48). From the result of the subscale *Training*, it portrayed a great difference between the two cohorts' opinions toward whether their own sport injury was related to their overall training environment and conditions. The German cohort disagreed with a mean score of 1.57 while the Taiwan cohort confirmed with a mean score of 3.59. The result of *ILE* scale (40 questions total score) indicated that the German cohort scored 5.44 while the Taiwanese cohort scored 3.86; this

presented a significant differences on accumulated stress levels from life events of two elite athlete cohorts. This result was also confirmed by overall Spearman correlation test between “experience levels” and *ILE*. All 5 levels of elite athletes’ experiences on international competitions resulted in a significant correlation with *ILE* (Summer OG $\rho=.154$, Winter OG $\rho=.148$, Summer & Winter OG $\rho=.139$, World Championship $\rho=.282$, International Championship $\rho=.277$, all p values $<.01$). A result which could also explained with regards to Olympic Games which were defined as critical life events of some authors (Conzelmann & Gabler, 1998).

The second hypothesis was verified revealing that influencing factors existed, which was demonstrated by many variables achieving a level of significance during logistic and multiple regression analyses. Variables such as age, sport types, experience levels, were best candidates as influencing factors for analyzing the different results between German and Taiwanese participants. The influencing effect from sport type_format on body injury outcome was confirmed statistically, other influencing variables presumably to have same effects. The influence of scale as the moderating factors on the *Injury Frequency* scale also observed from the scales of *PHE* & *PPE* as well as the *ILE*. The results are in line with the theoretical framework set forth by the International Olympic Committee, which was published in the consensus statement for health promotion and injury prevention for elite athletes (Ljungqvist et al. 2009). Furthermore, they showed that injuries are multifactorial which include psycho-social and social-environmental factors (Anderson & Williams 1988, Steffen, Pensgaard & Bahr 2009) and they cover different aspects of one’s lifespan (Bahr & Holme 2003, Siegrist & Geyer 2014).

The third hypothesis assumed that interaction of influencing factor(s) existed. This was confirmed and demonstrated by testing the influencing factor “sport type_format” and 2 scales in the general linear regression model for main effect and interaction tests. The scale “*Injury Caused Losses*” demonstrated a significant difference, although, not when interacting with the influencing factor “sport type_format” as a whole (but significant levels were reached when treated with each internal category of “sport type_format” respectively). However, when the interaction test switched variable to other scale (e.g. *Medical Care Support (Variety & Frequency)*) the significant level resumed for scale *Injury Caused Losses* in the model. This meant for further investigation on injury related variable and risk factors, interaction effect from influencing factor(s) should be considered and controlled.

Limitations: 1) for the interpretation of the results it is important to consider that the sport systems in both countries are different regarding the supporting resources and training environment available to athletes. 2). It is also necessary to consider the differences of social traditions and natural climate of both countries lead to different distributions of sport types and physical activities of athletes. 3) Noticeably, the sample cohorts under study were different in age and sample sizes. For reduction of limitation 2 and 3, controlled perspectives (age, sport types) with help of statistical methods in different analysis steps were adapted.

5.2.6 Conclusion

In summary, this study successfully presented the feasibility of a multi-discipline integrated evaluation instrument, and approach in injury risk factor analysis, for elite level athletes. This study showed that different injury related factors can be found in a comparison between relatively heterogeneous elite athlete cohorts. It was also demonstrated that the influencing factors and interactions did exist in the complex interrelationship among all relevant factors surrounding athletes. This was also suggested by different authors and associations such as the IOC. To gain more information about this complex topic further investigation (respective interventional design) are still needed for a better understanding of the causes and consequences, as well as mechanisms, of injuries and possible prevention factors. Further investigation on other influential factors such as medical care support and coaches' training also necessary for better understanding on these issues.

5.2.7 References

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5.3 Study 3

PERSPECTIVE OF MEDICAL CARE PROVIDERS ON ELITE ATHLETE INJURY PRE-PARTICIPATION EXAMINATION AND PERIODIC HEALTH EVALUATION

Victor C. Wang¹, Frank Mayer¹, Pia M. Wippert²

¹ Department of Sport Medicine and Sport Orthopaedics, University Potsdam, Potsdam 14469, Germany

² Department of Sociology of Physical Activity and Health, University Potsdam, Potsdam 14469, Germany

Reference

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5.3.1. Abstract

In 2009, the International Olympic Committee (IOC) published a consensus statement on elite athletes' Pre-participation Examination (PPE) and Periodic Health Evaluation (PHE). However, these criteria have not been standardized. This study thus purposed three aims: 1. to determine whether significant differences exist in the Pre-participation Examination (PPE) & Periodic Health Evaluation (PHE) scales between German and Taiwanese medical care providers (MCPs); 2. to determine whether any significant differences exist among MCP cohorts' usages of or attitudes towards psychosocial factors during an athlete's injury and rehabilitation-related treatment; 3. to investigate the correlations between the scales employed. Eighty-six MCPs from Taiwan ($n=52$, 21♀, 31♂, age= 36.9 ± 10.3 yrs.) and Germany ($n=34$, 20♀, 14♂ age= 36.3 ± 8.2 yrs.) participated. Inclusion criteria required participant status as a current or retired MCP for national team athletes of Olympic sports. Descriptive statistics, Spearman correlation coefficients, Mann-Whitney U tests and Kruskal-Wallis 1-way ANOVA test were employed. Four parts were derived from the 1st hypothesis. Part 1: significant differences between German and Taiwanese cohorts' *PPE & PHE scales: Importance* and *Psychosocial Factor Scale* results. Part 2: Significant differences on scores for the *PPE & PHE Giving Scale and its 3 subscales* found between MCPs' positions. Part 3: Medical education/training showed no influencing effect on the outcome of 3 PPE & PHE-related scales. Part 4: German cohorts participated in regional international championships over twice as often as their Taiwanese counterparts. The results of the 2nd hypothesis showed that the *Psychosocial Factor Scale* portrayed significant differences in MCPs' nationalities, but this was not related to their experience levels, medical education/training or medical care position. The results of the 3rd hypothesis showed that the *Psychosocial Factor Scale* was significantly correlated with the *PPE & PHE Importance Scale*. This study concluded that medical education/training background is not a determining factor in the promotion of PPE & PHE-related core values. German cohorts' professional positions specifically reflected the IOC consensus statement-based PPE & PHE job assignments. Sports medicine doctors are mainly responsible. Overall, the national medical care environment could be a factor influencing cognitive outcomes of PPE & PHE and psychosocial related establishments. Life experience (age) seems more important than the degree of competition participation experience.

5.3.2 Introduction

Health is an indispensable pre-condition for athletes' peak performance, yet injury and illness are often the most devastating obstacles for elite athletes to achieve their goals. Moreover, health prevention for athletes seems to be a complex issue due to the different influencing factors of the injury risk. Because of the complexity of this multi-factorial issue (Bahr & Holme 2003), it is necessary to build a sound system of health promotion and injury-prevention by taking a series of comprehensive measures from both sides: athletes and medical care providers. This could stop injury or illness from occurring up until the end of the athlete's rehabilitation and return to play (Engebretsen & Bahr 2009).

In 2009, the International Olympic Committee (IOC) published a consensus statement on health promotion and injury prevention as recommendation criteria for international sport authorities and sports medicine professionals (Ljungqvist, Jenoure, Engebretsen, Alonso, Bahr & Clough 2009). The experts' consensus statement covers two major dimensions (cardiovascular and orthopaedic aspects of sports medicine) and focuses on two organized protocols: the Periodic Health Examination (PHE) and Pre-Participation Evaluation (PPE). Under the IOC's encouragement, many countries have adapted and followed these protocols in their national sport medicine practices and in training centres' medical and health-related systems. However, due to a lack of standardization in the experts' consensus, health evaluations and pre-participation examinations conducted for athletes using such criteria can only rely on qualitative methods and applications. Since 2011, standardized instruments for the IOC's recommended PPE and PHE criteria have been developed by Wang, Mayer, Ottawa & Wippert (Risk-IQ) which analyses risk factors in elite athlete injuries (Wang, Mayer, Ottawa & Wippert, 2015; Wang, Mayer & Wippert, 2015). Besides the IOC criteria, this questionnaire also includes further risk factors that have been identified in injury-related studies reported in the literature.

Due to the complexity of injury risk factors (Engebretsen & Bahr 2009), the focus of sports injury-related research over time has generated a greater range of diverse interests in injury prevention and identifying risk factors (Andersen & Williams 1988, Corrado, Basso, Schiavon, Pelliccia & Thiene 2008). Over the years, many investigations have been conducted by various groups of sports scientists to analyse psychosocial characteristics as well as the social environment as risk factors for elite athlete injury (Andersen & Williams 1988, Steffen, Pensgaard & Bahr 2009, Wiese-Bjornstal, Smith, Shaffer & Morrey 1998).

Numerous authors have indicated that the roles of medical care providers (MCPs) who are engaged in athletic health- or injury-related issues is often considered as a significant influencing

factor in injury- and rehabilitation-related studies (Herring, Bernhardt, Boyajian-O'Neill, Gerbino, Jaffe, Joy et al. 2007, Pearsall, Kovaleski & Madanagopal 2005). MCPs act as investigators, handlers, evaluators and sometimes definition-makers (i.e. severity level of injury) in each athlete's injury case. Nevertheless, MCPs for elite athlete health care services in fact involves different medical professional cohorts who possess a range of different types of medical training, experience, backgrounds, PHE/PPE-related job assignments and expected tasks in their professional positions, which also means that the interactions between athlete-patients and various MCP cohorts are often multi-faceted and interactive (Mann, Grana, Indelicato, O'Neill & George, 2007). However, there is still a lack of knowledge in the literature related to the systematic investigation of the effects and interaction of various MCP cohorts concerning elite athletic injury-related issues, and on the effect of existing differences in medical care systems and overall environment between countries regarding their elite athletes' PHE/PPE medical care services.

Psychosocial factors have been shown to be an important antecedent to the onset of athletic injuries, and also play an important role in injury rehabilitation and, ultimately, successful return-to-play. (Cramer-Roh & Perna 2000, Mann, Grana, Indelicato, O'Neill & George, 2007). However, psychosocial factors and considerations particularly from the MCPs perspectives on injury prevention and post-injury rehabilitation have often been left out of recommended protocols for injury prevention and rehabilitation, as recent studies have pointed out (Herring, Boyajian-O'Neill, Coppel, Daniels, Gould, & Grana et al 2006, Cramer-Roh & Perna 2000).

Due to training and cultural conditions, it was assumed that there could be a difference between these two countries. Therefore, it was of interest whether an international guideline could be taken into account in the same manner in two totally different cultures. Furthermore, what should be considered if the sports system were to be restructured? Is there any area which could benefit from new knowledge in this regards? To date, the IOC consensus statement recommended criteria for medical care domains and training systems has been adapted accordingly in Germany; only partial criteria in medical care support and training environment-related practices were adapted in Taiwan. Therefore, more in-depth knowledge is needed for a better understanding of the various effects caused by these differences.

The significance of comparing MCPs cohorts from Taiwan and Germany is based on two factors. First, as a compatible extension of the Risk-IQ study for elite athlete injury risk and PPE/PHE-related topics, according to the literature (Cramer-Roh & Perna 2000, Pearsall, Kovaleski & Madanagopal 2005), the results of the MCPs study, may be directly or indirectly related to the results of the Risk-IQ study. Second, since the systematic difference in MCP-related environments

between German and Taiwan has never been investigated, one hypothesis of this study was to identify the possible correlations or interactions in the MCP systems of the two countries, which could be a moderator to the findings of the MCP study and influence the results of the elite athlete study.

The present study is the attempt to fill the gap in this particular knowledge; the aims of the paper are threefold. Analysis was undertaken to determine whether:

1. There are a) significant differences in PPE & PHE scales between German and Taiwanese MCP cohorts and, further, whether these differences are related to their b) medical education/trainings, c) medical care positions, or d) experience levels.
2. There are significant differences among the MCP cohorts' usage of and attitudes towards psychosocial factors involved in an athlete's injury and rehabilitation treatment.
3. There are significant correlations between scales employed in medical care perspective questionnaire (MCPQ) and MCP-related influencing factors (such as medical education, job position, and experience participating in international competition).

5.3.3 Material and methods

5.3.3.1 Participants

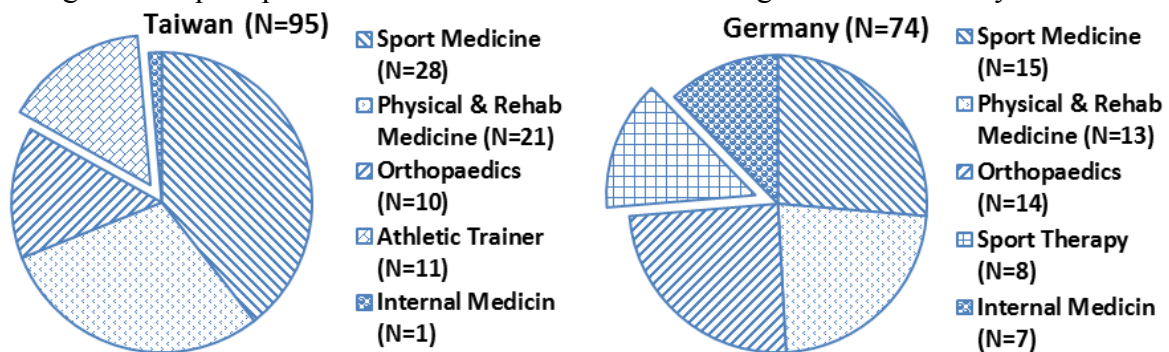
Eighty-six MCPs [n=52 Taiwanese (TW); 21 female (34.86 ± 7.3 yrs.), 31 male (38.23 ± 11.9 yrs.), and n=34 German (DE); 20 female (31.95 ± 4.9 yrs.), 14 male (42.57 ± 7.9 yrs.)] were recruited from national training centers, regional hospitals, universities and clinics participated. The positions of MCPs were distributed such that 30 were doctors, 20 athletic trainers (only Taiwan), 23, physical therapists, 8 sport therapists (only Germany) and 5 medical assistants. The inclusion criteria specified all medical related professionals and current or retired national sports team MCPs, who provided their expertise to handle medical related injury and illness issues of elite athletes (on the basis of first line contact with athletes during training or competition periods) were all included as potential recruiting targets for participating in this study. The distribution of participants' gender, overall age and overall experience level between German and Taiwanese were homogenous, except for two pairwise age (combined) comparisons between medical doctor (42.57 ± 10.0 yrs.) and athlete trainer (33.90 ± 9.9 yrs. $p=.023$) and between medical doctor and physical therapist (33.26 ± 6.7 yrs. $p=.020$) groups.

5.3.3.2 Study procedure

For this cross-sectional study, medical care providers for national team-level elite athletes were recruited and the evaluation was anonymously conducted via postal correspondence through na-

tionwide sports training centers, regional hospitals, clinics, universities and sports federation networks in both Germany and Taiwan. An individual package, consisting of an invitation letter, an explanatory note/flyer, a questionnaire, and a postage-paid return-addressed envelope, was provided for each participant. Each participant's completed questionnaire was sealed individually and data was treated confidentially by following privacy protection protocol. Due to the incompatibilities of two cohorts (athletic trainers) in Taiwan and (sport therapists) in Germany (Figure 9), these two cohorts were not compared nor grouped together. Instead, they stood independently with their own group names under conditions entitled "nationalities combined (DE+TW)" (as shown in Table 11, Table 12 and Table 13)

Figure 9. Top-5 options of main medical education backgrounds of MCP by countries



5.3.3.3 Instrument – Medical Care Provider Questionnaire (MCPQ)

The MCPQ developed for this study based on the 2009 IOC Consensus Statement criteria is an interdisciplinary questionnaire with a good overall test-retest reliability ($ICC = .79$) and good correlation coefficients (German version Spearman $\rho = 0.63-0.91$, Taiwanese version $\rho = 0.68-0.94$). The predominately medically oriented content was pre-defined by worldwide medical professionals (Ljungqvist et al., 2009), later further supported by the Risk-IQ study (Wang, Mayer, Ottawa & Wippert 2015), and minimally affected by either cultural bias or language barriers. Two bilingual investigators were integrated into the MCPQ study. However, cultural adaption of the questionnaire was not necessary due to the use of pre-determined IOC-recommended guidelines which adapted different cultures for the MCPQ's development. Meanwhile, the MCPQ was created and tested by a team of international (Taiwanese and German) medical care experts. For the present study, five scales of the MCPQ were used, namely the *International Competition Experience Scale*, the *Pre-participation Evaluation (PPE) & Periodical Health Evaluation (PHE) Giving Scale*, the *PPE & PHE Awareness Scale*, the *PPE & PHE Importance Scale* and the *Psychosocial Factor Scale* (Table 10).

Table 10 Internal consistency of scale and subscale of MCPQ

Scales and subscales used in MCPQ survey	# of Item	Score Range	Cronbach's Alpha
<i>International Competition Experience Scale</i>	4	0 - 22	.79.
<i>PPE & PHE Giving Scale (subscales I,II,III,IV)</i>			
<i>I. Cardiovascular subscale</i>	14	0 - 14	.94
<i>II. Orthopaedic subscale</i>	9	0 - 9	.97
<i>III. Clinical Examination Methods subscale</i>	6	0 - 6	.87
<i>IV. Other Test subscale</i>	11	0 - 11	.87
<i>PPE & PHE Awareness Scale</i>	2	0 - 2	.86
<i>PPE & PHE Importance Scale</i>	4	0 - 5	.64
<i>Psychosocial Factor Scale</i>	2	0 - 5	.63

MCPQ = medical care perspective questionnaire

International Competition Experience Scale: This scale contains four items on MCP's personal medical care expertise provided to athletes on various levels of international sport competitions, namely the Summer Olympic Games, Winter Olympic Games, World Championship/World Games, and other international competitions. The scale was built by adding frequencies of all levels of competition as the score, mean=2.7, (min=0, max=22). The Cronbach's alpha of this scale is .79.]

PPE & PHE Giving Scale: Based on the IOC consensus statement and contents from PPE and PHE-related documents PPE and PHE this sections contains four subscales, namely: I. the *Cardiovascular* subscale which consists of 14 dichotomic items [Have you provided Heart PPE items to athletes e.g. "Heart Rhythm", "Heart sounds", (min=0, max=14) Cronbach's alpha= .94]. II. the *Orthopaedic* subscale which consists of 9 dichotomic items [Have you provided orthopaedic PPE items to athletes e.g. "Neck", "Back", "Shoulder/arm", "Elbow/forearm", (min=0, max=9) Cronbach's alpha= .97]. III. the *Clinical Examination Methods* subscale which consists of 6 dichotomic items [What kind of PPE examination procedures did you provided to athletes? e.g. "Physical exam", "Palpation", "Range of motion test", (min=0, max=6) Cronbach's alpha= .87]. IV. the *Other Test* subscale which consists of 11 dichotomic items [What kind of examination method did you provided to athletes?, e.g. "Blood test", "X ray", "MRI", "CT scan", mean=2.3, (min=0, max=11) Cronbach's alpha= .87]. All four subscales frequencies (yes=1, no=0) of all items were calculated into scores.

PPE & PHE Awareness Scale: Based on the IOC consensus statement contents the PPE and PHE awareness scale consists of two dichotomic items regarding medical care providers' awareness of the overall PPE and PHE medical service items [e.g. "Are you aware of the content of Periodical Health Evaluation (PHE) in the IOC consensus statement of 2009?"]. The scale was built by adding

frequencies (yes =1, no=0) from both items as score. Mean=0.6, (min=0, max=2). The Cronbach's alpha= .86.

PPE & PHE Importance Scale: This scale consists of 4 items on a Likert scale (1=very important, 2=important, 3= no opinion, 4= not important, 5=totally not important") related to cardiovascular and orthopaedic PPE as well as psychosocial consideration and roll playing (example item: "How important do you think the Orthopaedic risk factor screening during pre-participation examination is to the injury prevention for elite athlete). The scale taken averaged ratings from the 4 items as the score (min=0, max=5) The Cronbach's alpha is .64.

Psychosocial Factor Scale: This consists of 2 items on a Likert scale (1=strongly agree, 2= agree, 3= no opinion, 4= disagree, 5= strongly disagree) measuring Psychosocial issues related to MCPs' perspectives on handling of matters related to an athlete's injury (e.g. "Do you agree that Psychosocial and Emotional reactions should be also be considered along with physiological condition in the decision making process regarding return to play for injured athletes? The scale was built by taking averaged ratings from 2 items as the score, (min=0, max=5). The Cronbach's alpha of the scale = .63.

5.3.3.4 Statistical analyses

For both hypothesis 1 and hypotheses 2, descriptive statistics were performed with the mean, SD and 95% confidence interval (CI). Mann-Whitney U tests were performed for 2-groups comparisons and Kruskal-Wallis 1-way ANOVA test were performed for comparisons involving more than 2 groups. Spearman correlation coefficients (ρ) were employed for nonparametric data in hypothesis 3. The significance level was set at $p < 0.05$. All statistical analyses were carried out using SPSS 22.0 (IBM SPSS Statistics 22, IBM, USA).

5.3.4 Results

5.3.4.1 Hypothesis 1.

Regarding the results of hypothesis 1 it can be summarized into 4 sub-groups:

5.3.4.1.1 National background

As to overall national background, German and Taiwanese MCP cohorts differed significantly on the *PPE & PHE Importance Scale* ($p=.034$) and *Psychosocial Factor Scale* ($p=.009$), but not on the *PPE & PHE Given Scale* ($p=.417$) or *International Competition Experience Scale* ($p=.584$).

5.3.4.1.2 Medical care position

With regard to medical care position, significant differences were found only for the *PPE & PHE Giving Scale* ($p=.002$). No significant differences were found in the results of the *PPE & PHE Importance Scale* and *PPE & PHE Awareness Scale* across different medical care positions. Results of the *PPE & PHE Giving Scale* revealed that 3 out of its 4 subscales reached significant difference levels when comparing different medical care positions: *Cardiovascular* ($p=.004$), *Orthopaedic* ($p=.006$) and, *Other Tests* ($p=.010$). All 3 PPE & PHE related scales tested with split data (German and Taiwanese data test separately), showed no significant differences among all Taiwanese cohorts in terms of their medical care positions. Significant differences were reached among German counterparts (*PPE & PHE Giving Scale*, $p=.006$); 2 pairwise comparisons reached significant levels: between sports therapists and medical doctors ($p=.022$), and between physical therapists and medical doctors ($p=.016$) in German MCP cohorts.

Table 11 Comparison of PPE & PHE experiences of German and Taiwanese MCP cohorts

Country	MCP Position	"Yes"- PHE	"Yes"-PPE	Either	Neither	Both	Total
TW	Medical Doctor	70.6 (23.1)%	29.4 (9.6)%	64.7 (21.2)%	17.6 (5.8)%	17.6 (5.8)%	32.7%[n=17]
	Athletic Trainer	30 (11.5)%	45 (17.3)%	45 (17.3)%	35 (13.5)%	15 (5.8)%	36.6%[n=19]
	Physical Therapist	38.5 (9.6)%	23.1 (5.8)%	53 (13.5)%	38.5 (9.6)%	7.7 (1.9)%	25%[n=13]
	Sport Therapist	NA	NA	NA	NA	NA	NA
	Med Assistant	100 (1.9)%	0 (0)%	50 (1.9)%	50 (1.9)%	0 (0)%	3.8%[n=2]
	(Combined)	46.2 %	32.7 %	53.8 %	30.8 %	13.5 %	98.1%[n=51]
DE	Medical Doctor	100 (38.2)%	84.6	15.4 (5.9)%	0 (0)%	84.6 (32.4)%	38.2%[n=13]
	Athletic Trainer	NA	NA	NA	NA	NA	NA
	Physical Therapist	50 (14.7)%	20 (5.9)%	50 (14.7)%	40 (11.8)%	10 (2.9)%	29.4%[n=10]
	Sport Therapist	50 (11.8)%	37.5 (8.8)%	12.5 (2.9)%	50 (11.8)%	37.5 (8.8)%	23.5%[n=8]
	Med Assistant	66.7 (5.9)%	33.3 (2.9)%	33.3 (2.9)%	33.3 (2.9)%	33.3 (2.9)%	8.8%[n=3]
	(Combined)	70.6 %	50 %	26.5 %	26.5 %	47.1 %	100%[n=34]
TW + DE	Medical Doctor	83.3 (29.1)%	53.3	43.3 (15.1)%	10 (3.5)%	46.7 (16.3)%	34.9%[n=30]
	Athletic Trainer	30 (12.5)%	45 (10.5)%	45 (10.5)%	35 (8.1)%	15 (3.5)%	22.1%[n=19]
	Physical Therapist	43.5	21.7 (5.8)%	52.2 (14)%	39.1 (10.5)%	8.7 (2.3)%	26.7%[n=23]
	Sport Therapist	50 (4.7)%	37.5 (3.5)%	12.5 (1.2)%	50 (4.7)%	37.5 (3.5)%	9.3%[n=8]
	Med Assistant	75 (3.5)%	25 (1.2)%	50 (2.3)%	62.5 (2.4)%	25 (1.2)%	5.9%[n=5]
	(Combined)	55.8 %	39.5 %	43 %	29.1 %	26.7 %	98.8%[n=85]

NA – Not applicable (calculated in times of participation)

5.3.4.1.3 Medical education/training

With regard to medical education/training, descriptive statistics reflecting the recruited cohorts recorded the top-5 ranked medical education/training backgrounds (3 options allowed) with counts and percentages from all participating MCP cohorts combined - [German]: 1. Sports Medicine ($n=15$, 44.1%), 2. Orthopaedics ($n=14$, 41.2%), 3. Physical & Rehab Medicine ($n=13$, 38.2%), 4. Sports Therapy ($n=8$, 13.5%), 5. Internal Medicine ($n=7$, 20.6%); [Taiwan]: 1. Sports Medicine ($n=28$, 53.8%), 2. Physical & Rehab Medicine ($n=21$, 40.4%), 3. Sports Therapy ($n=11$, 21.2%), 4. Ortho-

paedics (n=10, 19.2%), 5. Others (n=5, 9.6%). Both combined and split data showed that none of the 3 PPE & PHR--related scales significantly differed across MCPs' various medical education/training backgrounds (all $p>.05$). All 4 subscales (1.*Cardiovascular*, 2.*Orthopaedic*, 3.*Clinic Exam Method* and 4.*Other Tests*) of the *PPE and PHE Giving Scale* also showed no significant differences in terms of cohorts' medical education/training (all $p>.05$).

5.3.4.1.4 Experience levels

With regard to experience levels, the experience levels were defined by Criteria I: *International Competition Experience Scale* (Table 12) and Criteria II: *Number (in groups) of medical care services given to athlete* (Table 13). Criteria I was tested between German and Taiwanese MCP cohorts. Results showed that only experience in "other international competitions" reached significant difference levels between German and Taiwanese (DE: $M=3.4\pm3.3$; TW: $M=1.5\pm1.1$, $p=.041$) MCP cohorts. Three PPE & PHE--related scales tested with experience criteria revealed that only the *PPE & PHE Giving Scale* showed significant differences in a comparison between Criteria II groups ($p=.043$)

Table 12 International competition participation experience by MCP cohorts

Country	MCP Position	# of OG/WOG	# of WC	# of other IC
TW	Medical Doctor	2.5 \pm 2.1	2.5 \pm 1.0	1.3 \pm 0.7
	Athletic Trainer	2.8 \pm 1.9	7.5 \pm 7.5	1.9 \pm 1.5
	Physical Therapist	0	1.8 \pm 1.0	1.0 \pm 0
	Sport Therapist	NA	NA	NA
	Med Assistant	0	0	0
	(Combined)	2.7 \pm 1.8	4.6 \pm 5.6	1.5 \pm 1.1
DE	Medical Doctor	1.5 \pm 0.7	3.0 \pm 3.2	4.7 \pm 4.6
	Athletic Trainer	NA	NA	NA
	Physical Therapist	1	2.2 \pm 0.8	2.6 \pm 1.5
	Sport Therapist	0	3	2.3 \pm 1.8
	Med Assistant	0	0	0
	(Combined)	1.3 \pm 0.6	2.7 \pm 2.2	3.4 \pm 3.3
TW + DE	Medical Doctor	2.0 \pm 1.4	2.8 \pm 2.3	2.6 \pm 3.2
	Athletic Trainer	2.8 \pm 1.9	7.5 \pm 7.5	1.9 \pm 1.5
	Physical Therapist	1	2.1 \pm 0.9	1.6 \pm 1.2
	Sport Therapist	0	3	2.3 \pm 1.8
	Med Assistant	0	0	0
	(Combined)	2.4 \pm 1.7	3.8 \pm 4.6	2.1 \pm 2.2

OG –Olympic Games, WOG –Winter Olympic Games,
WC –World Championship, IC – International (&Regional) Championship
NA – Not applicable (calculated in times of participation)

Table 13 Medical care service given experience by MCP cohorts

Country	MCP Position	1-100	100-500	500-1,000	1,000+	Total
TW	Medical Doctor	7 (13.5%)	2 (3.8%)	2 (3.8%)	6 (11.5%)	17 (32.7%)
	Athletic Trainer	2 (3.8%)	6 (11.5%)	8 (15.4%)	4 (7.7%)	20 (38.5%)
	Physical Therapist	6 (11.5%)	4 (7.7%)	3 (5.8%)	0 (0%)	13 (25%)
	Sport Therapist	NA	NA	NA	NA	NA
	Med Assistant	1 (1.9%)	1 (1.9%)	0 (0%)	0 (0%)	2 (3.8%)
	(Combined)	16 (30.8%)(1)	13 (25%)(2)	13 (25%)(2)	10 (19.2%)	52 (100%)
DE	Medical Doctor	1 (2.9%)	5 (14.7%)	1 (2.9%)	6 (17.6%)	13 (38.2%)
	Athletic Trainer	NA	NA	NA	NA	NA
	Physical Therapist	1 (2.9%)	0 (0%)	4 (11.8%)	5 (14.7%)	10 (29.4%)
	Sport Therapist	1 (2.9%)	2 (5.9%)	5 (14.7%)	0 (0%)	8 (23.5%)
	Med Assistant	2 (5.9%)	0 (0%)	1 (2.9%)	0 (0%)	3 (8.8%)
	(Combined)	5 (14.7%)	7 (20.6%)(3)	11 (32.4%)(1)	11 (32.4%)(1)	34 (100%)
TW + DE	Medical Doctor	8 (9.3%)	7 (8.1%)	3 (3.5%)	12 (14%)	30 (34.9%)
	Athletic Trainer	2 (2.3%)	6 (7%)	8 (9.3%)	4 (4.7%)	20 (23.3%)
	Physical Therapist	7 (8.1%)	4 (4.7%)	7 (8.1%)	5 (5.8%)	23 (26.7%)
	Sport Therapist	1 (1.2%)	2 (2.3%)	5 (5.8%)	0 (0%)	8 (9.3%)
	Med Assistant	3 (3.5%)	1 (1.2%)	1 (1.2%)	0 (0%)	5 (5.9%)
	(Combined)	21 (24.4%)(2)	20 (23.3%)	24 (27.9%)(1)	21 (24.4%)(2)	86 (100%)

NA – Not applicable (calculated in times of participation)

5.3.4.2 Hypothesis 2.

Regarding the results of hypothesis 2, the results of the *Psychosocial Factor Scale* indicated a significant difference between German and Taiwanese MCP cohorts ($p=.009$), which was not related to their medical education/training or medical care position. The results of the *Psychosocial Factor Scale* via Kruskal-Wallis test reached significant differences on the *PPE & PHE Importance Scale* ($p<.01$) in its 3 subscale items (*Cardiovascular PPE*, $p<.01$; *Orthopaedic PPE*, $p<.01$ and *Role Playing*, $p<.05$). It did not show a significant difference between Criteria I experience level groups ($p>.05$), as well as on the “Awareness of PPE & PHE content” factor ($p>.05$).

5.3.4.3 Hypothesis 3.

Regarding the results of hypothesis 3, the results of the Spearman correlation indicated that the *Psychosocial Factor Scale* was significantly correlated with the *PPE & PHE Importance Scale* ($\rho=.769$, $p<.01$). “Age” was significantly correlated with the *International Competition Experience Scale* ($\rho=.484$, $p<.01$), “*PPE & PHE Giving Scale*” ($\rho=.321$, $p<.01$), “*PPE & PHE Importance Scale*” ($\rho=-.221$, $p<.05$), and “*Psychosocial Factor Scale*” ($\rho=-.267$, $p<.05$).

5.3.5 Discussion

5.3.5.1 Hypothesis 1

The first part (part a) of hypothesis 1 assumed significant differences with respect to medical education background, medical care position and experiences levels between German and Taiwanese medical care provider cohorts, which are especially reflected in the *PPE & PHE Importance Scale* and *Psychosocial Factor Scale*. German MCP cohorts overall reported higher scores than their Taiwanese counterparts on these two scales, which reflected the differences between the two countries in terms of promotion of PPE and PHE and, therefore, the IOC-related medical establishment for athletic injury prevention and risk factor screening. These significant differences could be attributed to structural differences in the sports medicine-related programs between the two countries on three points: 1. the IOC consensus statement-based PPE/PHE program has been established in Germany but not totally established in Taiwan. 2. Professional sports physician/doctor and sports therapist programs were institutionalized in Germany but not in Taiwan, while athlete trainer program were established in Taiwan but not in Germany. 3. Different roles and functions of physical therapists were shown between Taiwan (both athlete and community-oriented) and Germany (more community-oriented). The second part of the results (part b) also confirmed that only the German medical doctor cohort reported significantly higher *PPE & PHE Giving Scale* scores than the other 2 German MCP cohorts (sport therapist and physical therapists); all other PPE & PHE--related scales showed otherwise. This portrayed not only a characteristic difference in medical doctors' professional job assignments between Germany and Taiwan, but also the fact that German medical doctors were giving more PPE/PHE--related tests than their German and Taiwanese MCP cohorts counterparts. This result reflected the fact that the IOC consensus recommended PPE/PHE screening protocol was established in Germany but not totally established in Taiwan, and the main executors of the program were sports medicine doctors. The third part of the results (part c) of hypothesis 1 revealed that medical education/training was not a significant factor affecting the outcome of all 3 PPE & PHE--related scales in this study. Probable attribution was due to the fact that most PPE/PHE--related medical care services provided to athletes, were made possible only by the efforts and cooperation between MCP teams. For the fourth part of the first hypothesis (part d), the results of Criteria I indicated that the significant difference in experience levels did exist between German and Taiwanese MCP cohorts, mainly for continental/regional international championships but not for the Olympic and World-Championship levels. Overall, German cohorts reported a slightly more than 2-fold mean participation experience than their Taiwanese counterparts in providing medical care services in regional international champi-

onships. This finding reflected that the actual MCP cohorts' international competition opportunities/experiences were directly correlated with the national-level elite athletes' international competition opportunities/experience of the same country. Overall German elite athletes reported a similar superior (higher) averaged ratio for participation in international competition than their Taiwanese counterparts (Wang, Mayer & Wippert, 2015). The Criteria II result indicated that the significant difference in experience levels was reflected only on the *PPE & PHE Giving Scale* in this study, which confirmed with results from the second part of this hypothesis.

5.3.5.2 Hypothesis 2

As for the second hypothesis, the results of the *Psychosocial Factor Scale* differed significantly between the German and Taiwanese groups, but were not influenced by MCPs' personal experience levels, medical education/training or professional positions. This reflected the fact that MCP cohorts' nationality was a moderator of their own background variables of the psychosocial results. Furthermore, the *Psychosocial Factor Scale* results indicated a significant difference on the *PPE & PHE Importance Scale* (3 subscales: Cardiovascular PPE, Orthopaedic PPE and Role Playing), which showed the connection between the psychosocial factors of the two scales.

5.3.5.3 Hypothesis 3

Regarding the results of the third hypothesis, although only the *Psychosocial Factor Scale* indicated a significant, relatively strong correlation with the *PPE & PHE Importance Scale* among all scales employed, the results nevertheless also revealed the prevalent associations between the 4 scales used in the MCPQ and the influencing factor of age. This result showed that the MCP cohorts' age was significantly, positively correlated with the *PPE & PHE Giving Scale* and the *International Competition Experience Scale*, but was significantly, negatively correlated with the *PPE & PHE Importance Scale* and *Psychosocial Factor Scale*. In other words, as life experience increased among MCPs in this study, they tended more often to give athletes the PPE and PHE. Also, they participated more in medical care services during international sport competitions; on the other hand, their opinion towards the importance of PPE/PHE and psychosocial factors tended to decrease. MCPs' professional perspectives on the importance of PPE/PHE and psychosocial factors related to an athlete's injury and rehabilitation process seem like they could be changed over time.

5.3.5.4 Clinical implication of study finding:

The clinical implications of these findings showed two future directions: 1. In terms of closing discrepancies between overall German MCP and Taiwan MCP cohorts, there are several steps for national/state administration (in this study, Taiwan) to take, such as planning and implementing

medical and health care system up to IOC--recommended standard for elite-level athlete in order to narrow the gap between the current status and global criteria. This will also allow the inconsistency among MCP cohorts within the country to be minimized. 2. In terms of specific steps allowing better implementation of the IOC consensus, there are many possible options for international cooperation and/or exchange programs for implementation of this goal, such as international sports medicine exchange programs within the IOC structure which allow sharing of PPE/PHE know-how from an up-to-standard country (i.e. Germany) and learning opportunities for an under-the-standard country (i.e. Taiwan) regarding such protocols. Another is through the hosting of an international/regional conference, particularly on the PPE/PHE, injury prevention and health promotional topics. These above-mentioned options will further open up opportunities for the interchanges and promotion of IOC consensus ideas at in-depth levels.

5.3.5.5 Limitations of the study:

1) there was a small number of recruited participants, which might result in a reduced statistical power derived from the combination of smaller MCP groups and a low compliance rate on some particular questions. 2) There is an uneven distribution of MCP group participants, which was partially attributed to original differences in medical care systems and overall social environments existing between Germany and Taiwan. 3) Although the recruited participants were not matched group-by-group due to differences in the national medical care systems, the validity of analysis was not compromised in comparisons including variables such as country, medical education/training, medical care position and MCP experience levels.

5.3.6 Conclusions

Overall, this study connected the IOC consensus statement--based PPE and PHE focus points on the "Elite Athlete Risk of Injury Questionnaire (Risk-IQ)" study (Wang, Mayer, Ottawa & Wippert 2015) with medical care providers' perspectives. It was demonstrated in this study that, in the promotion of elite athletes' injury prevention programs in medical care communities worldwide, various factors or potential obstacles may influence the efforts and final results of athletes' health. This study concluded that medical education and training are not a determining factor in the promotion of PPE & PHE--related core values. German cohorts' professional positions reflected specific IOC consensus statement--based PPE & PHE job assignments. Sports medicine doctors take on the main responsibility. Overall, the national medical care environment could be a factor influencing the cognitive outcomes of the PPE & PHE and psychosocially related establishments. It is notable that the age of the MCP (and a certain kind of life experience) is more important than the ex-

perience level (defined as competition experiences in this study). As the saying goes: “It takes a village to raise a child.”. Similarly, it takes various MCP cohorts from different medical care communities to promote health and injury prevention for elite athletes. Cooperation and teamwork between different medical care professionals are essential for a successful program in its effort to overcome hindrances from potential social, environmental and culture differences.

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6. GENERAL DISCUSSION

<Study 1>. The results of first study provided the supporting evidence for its hypotheses:

1. The validity and test-retest reliability of Risk-IQ for German and Taiwanese elite athletes appeared in good to excellent standards. The significance of this result meant it was feasible to develop a functionally and linguistically valid injury risk evaluation tool (Risk-IQ questionnaire) based on the PHE and PPE criteria described in the IOC consensus statement (Ljungqvist, et al., 2009) for elite athlete, closing the gaps of evidence levels between expert-opinion based criteria and standardized questionnaire measures.
2. Further, this innovative, multidisciplinary questionnaire provided standardized and evidence based criteria for injury and illness surveillance measure for elite athlete during their training periods, complimented the void from the injury surveillance systems established since last two decades for multisport international competitions (Engebretsen, et al., 2013; Junge, et al., 2008; Junge, et al., 2004; Meeuwisse & Love, 1998).
3. The Risk-IQ's translation reliability tested between two different countries (Germany and Taiwan) and two different languages (German and Traditional Chinese), reported in excellent standard, which meant there were no culture barriers (Lee et al. 2009, Beaton et al. 2007) or linguistic bias between two versions of Risk-IQ. The possible reason attributed to the majority of content was medical oriented and less cultural content involved in Risk-IQ.

<Study 2>. Through utilization of the two linguistic versions of Risk-IQ, the second study investigated elite athletes' injury related risk factors in their training periods. In respect to its hypothesis, the results of second study revealed:

1. Injury records of 6 body parts (head, neck, back, knee, lower leg & feet) and total of 10 body parts injury records reached significant difference level between elite athlete cohort of Taiwan and cohort of Germany. ($p < .05$)
2. There were significant differences between German and Taiwanese elite athlete cohorts in various injuries and illness related risk factors (Wang et al. 2015a) which were in accordance with many researchers' theories/findings that sport injuries, particularly in elite level, consist of multi-facet factors (Bahr & Holme 2003, Wiese-Bjornstal et al. 1998). Extrinsic risk factors (i.e. training environments, supporting medical resources), intrinsic risk factors (i.e. experience level) and intriguing conditions (i.e. training conditions, competition frequencies) in dif-

ferent countries portrayed in this thesis as inherent variables to the risk of injury and illness for elite athletes as Bahr & Holme (2003) theorized in their model. However, it was the main focus of the present thesis to find out more in-depth background and mechanism which caused the differences in terms of injury/illness risk factors between cohorts in these two countries.

3. Several injury/illness related factors (i.e. sport type, experience level, PHE/PPE receiving status) found significantly influencing the total injury frequency of elite athlete's disregard of their nationalities. Other injury/illness risk factor (i.e. ILE stress level) found significantly influencing injury frequency of specified body region (Wang et al. 2015a, Wang et al. 2015c). However, due to the scopes of injury/illness related risk factors and their inter-correlations, interactions were not all covered in the present thesis, further potential moderating factors and interactions still awaits for later analysis from the great amount of datasets generated from this study. As Wiese-Bjornstal et al. (1998) suggested control group study to clarify the moderating effects and interaction among factors, it helped to point out that randomized control trial for interventional injury prevention training as depicted in Finch's TRIPP model step 3 (Finch 2006), and will facilitate the finding of significant risk factor from this study for future research direction.
4. Top-5 injury contributing risk factors in this study were: 1. Experience Level (international competition); 2. Number of PHE & PPE received; 3. Sport Types; 4. Stress from life event; 5. Age. Due to possible sampling bias might have been existed in recruited participants from both countries, this result is limited to this study and may not be concluded as a generalised finding.
5. As the potential interaction pattern illustrated in the four-phase-flow diagram, interactions from multiple injury/illness risk related factors (i.e. Stress and Sport Type) found significantly influenced the result of injury frequencies in both (DE & TW) elite athlete cohorts combined. However, it was not totally clear whether other influencing factor (i.e. nationality, experience level, or PPE-PHE receiving status), separate or together, would be the moderator(s) interacting and affecting the result of injury/illness risk. Unfortunately, there was no related research finding on this particular aspect found in literature. Further in depth analysis based in this present thesis is needed.
6. Another notable situation was the data collection design in the table of injury frequency for 10 body parts. Participants were expected to provide bodily injury frequencies in the past into many smaller blank boxes in 10 body parts; each body part contains 6 to 8 different types of

possible injury/illness. Such format of data acquisition had pre-set the condition of non-parametric data analysis to lower Spearmann correlation values (in present thesis, the ρ values ranged from .001 to .451). Such phenomenon was caused by the relatively smaller ratios compared from the variance of injured answers to the variance of “zero-filled” non-injured answer, especially when the few-injury and non-injured athletes are the majority in norm population. Jacob Cohen has written this topic in his book and suggested that a correlation of 0.5 is large, 0.3 is moderate, and 0.1 is small (Cohen, 1988) in terms of magnitude of effect. This should be respected while interpreting the results.

<Study 3>. The third study investigated the relationship between the results of PPE/PHE related scales, MCPs’ background, opinion and handling on these factors. The results of the third study showed that:

1. There were significant differences on the results of *PPE & PHE importance scales* between German (considered PPE&PHE more important) and Taiwanese (considered PPE&PHE less important) MCP cohorts. These differences were not related to their medical education/trainings background; instead, related to their medical care job positions, professional experiences levels. German sport medicine doctors shared more main responsibility on giving specific IOC consensus statement based PPE & PHE job assignments than their MCP counterparts in Germany and in Taiwan. These results revealed that not only overall national medical system but also medical care job position (which imbedded with age factor) were both determinant variables for promotion of elite athlete injury/illness preventive PPE/PHE screening. Unfortunately, no similar finding of this regard was found in literature up to date, and it was not reported either in a survey conducted within single country conducted by Mann et al. (2007).
2. The results of *Psychosocial Factor Scale* indicated German overall MCP cohorts scored significantly lower (considered “more important” or “more agree” to the questions) than Taiwanese overall MCP counterparts. Such finding was similar to the first conclusion that national medical/MCP related environment was a significant variable. Further, *Psychosocial Factor Scale* results reflected significant differences on MCP cohorts’ results of *PPE & PHE Importance Scale* (for all 3 subscales: *Cardiovascular PPE*, *Orthopaedic PPE* and *Role Playing*, German MCP cohorts selected more “necessary” options) which indicated the connection between these two scales.
3. There are significant correlations and possible interaction between employed scales in MCPQ survey and MCP related influencing factors. For instance, the result of Spearman correlation indicated that *Psychosocial Factor Scale* significant correlated with *PPE & PHE Importance Scale* but when considered separately, these results did not reflected on MCP groups’ person-

al experience level, medical education/training and professional job position. “Age” was an imbedded factor within MCP’s professional job positions, in MCPQ survey age was found significantly correlated with *International Competition Experience Scale*, *PPE & PHE Giving Scale*, *PPE & PHE Importance Scale*, and *Psychosocial Factor Scale*. Therefore, when MCP’s job position and age factors considered together, they are likely to interact with MCP’s experiences (both “international competition participation” and “PPE/PHE giving”) as well as cognitive aspects (importance and psychosocial concern) of PPE & PHE related factors. The significance of this finding was the co-construction built between Risk-IQ and MCPQ for elite athlete injury/illness related risk and psychosocial factors, allowing both innovated questionnaires to have a cross-reference point based on IOC consensus statement recommended content. However, as the four phase diagram depicted, these results and findings only fulfilled the requirements between beginning phases, further in-depth analysis needed for better understanding of these mutual relationships and the connection to MCP’s perspectives, particularly factors related to athletes injury/illness risks, rehabilitation and return to play decisions.

7. PRACTICAL RELEVANCE

In terms of practical relevance of the results from this thesis, there are some important points to be noted. From injury prevention and health promotion perspectives, the results revealed the prevalence of sport injury and related illness of elite athlete during their training phases. Comparatively, these findings could fill the void from the sport injury/illness surveillance systems which been designed and applied only for major international competitions. Additionally, the creation and conduction of both Risk-IQ and MCPQ surveys demonstrated their instrumental values by conveying the expert-opinion-based consensus statement of PHE and PPE criteria into standardized and validated evaluation measures, provided empirical supporting evidence to the IOC sport medicine initiative, eventually, the results was found in accordance with the aim that IOC consensus statement 2009 proposed which emphasised the value and importance of promoting PPE and PHE for elite athletes.

Previously, FIFA cooperated together with sport medicine specialists, developed a comprehensive warm-up program (FIFA 11+) which targeted on knee injury prevention for female football players (Soligard et al. 2008). After tested with series of compliance studies, this program proved to be effective and became well accepted in national football injury prevention campaign in some countries (Junge et al. 2011). However, not all ISFs and/or NOCs have the same scale of resources to emulate FIFA's team efforts and following their pathway. It is one of the aims of this present thesis to provide essential information on injury/illness risk factor identification and injury aetiology and/or mechanism for specific higher risk sports and its top level participants. By completed the primary ground works from this study, the concluded results could effectively paying the way toward the building of interventional training program and evaluation process for some specific higher risk sports, as the example FIFA 11+ had demonstrated.

From scientific research and theoretical development point of view, these results from heterogeneous cohort's comparisons of these two surveys provided empirical data of injury/illness related risk aetiology and mechanism, which helped to identify higher injury and illness related risks from elite athletes' sport types and training background. Although a longitudinal study with randomized control trial design of interventional training as well as a verification process for such training program still needed in future extended projects from this thesis, the role this present thesis playing

was essentially as taking the first two steps in an attempt to complete the full cycle of the 4-steps model (von Mechelen, 1992) or 6-step model (Finch 2006) suggested by previous studies. Nevertheless, the present results and information can still be utilized by athletes, coaches, medical care providers as well as related stakeholders for better their efforts in injury prevention, health promotional and eventually, peak performance enhancement.

Lastly, for the future research and development perspective, the additional function derived from this study was that it may be used as an example for future injury/illness prevention research projects, particularly for elite athletes population, and to serve as a connecting bridge or a communicating channel between the mandates of IOC–Olympic Movement Medical Code (IOC 2009), practical needs of ISFs and/or NOCs as well as all stakeholders related to elite athletes. The practical tasks to carry out such missions including but not limited to: sharing sport medicine professional know-hows, applying most updated injury prevention and health promotion knowledges on medical initiative of PPE and PHE related initiatives (i.e. cardiovascular risk screening , risk factor identification tests), presumably, through NOC-Exchange program under IOC-Olympic Solidarity.

8. LIMITATIONS AND ASSUMPTIONS

There are some limitations and assumptions in the three studies of this thesis needed to be clarified:

Limitation:

1. Retrospective instead of prospective design of (Risk-IQ) questionnaire

Methodologically, 2 cross-sectional studies and 2 retrospective-plus-cross-sectional studies were conducted in the present thesis in order to compare cohorts from two countries (cross-sectional) and among their own recollection (retrospective) of injury risk related data sources. This approach may cause the investigation of injury and illness risk contributing factors to be obscured from the study, particularly for overuse or chronic injuries.

2. Barriers of recruiting

The most challenging limitation of this study was the recruit of participants for pilot study as well as for elite athlete's cohorts from both countries. Athletes as well as MCP's concerns over personal information protection and/or avoiding distraction from training were the main unfavorable factors. However, although the recruited participants were not group-by-group matched due to differences of national sports and medical care systems, the validity of analysis was not compromised in comparisons with new variables (i.e. sport format) created for Risk-IQ study.

3. Potentially biased sampling

Due to the volunteer-based participants recruitment, differences of sport organizational structure as well as social structure, it was not possible for randomized sampling or homogeneous, pairwised participant-matched cohorts of elite level from two countries.

4. Lower positive answering rate for injury records

Answers to the injury record (particularly Risk-IQ question #28) were unavoidable blank/empty since these questions were only meant for those had injury or severe injury (in case of CIRS) for self-reported data collection. This data format might play the role why the results of injury records related statistic analysis mostly appear with lower values (even when significant level reached).

5. Lower positive answering rate for stress scales (ILE & PSS)

Like the injury records, blank/empty answer were unavoidable expected in returned questionnaires since these questions were only meant for those who had experienced specified or related stress events.

6. Time-window effect

Low compliance rate of the Perceived Stress Scale which targeted only on 2012 London Olympic Games participants with a small validation time window of one year afterward, such combined conditions had pre-set the low compliance rate and low statistic power from analysis. Further, to the relatively broad possibilities, developing a test or questionnaire as the research procedure in this thesis was more explorative.

7. Theoretical and methodological limitation

In addition to the methodological limitations, the Risk-IQ survey had revealed some theoretical and conceptual limitations such as the memory accuracy diminishing effect of self-report survey as reported by Gabbe and colleagues (2003).

8. Exploratory methodological attempts

In this study, some of the statistical methods (multiple-logistic regressions) were exploratory attempts. Therefore no causation consequences were concluded through these methods.

Assumption:

1. Generalized linear relationship between variables.
2. Memory limitation assumed to have no effect.

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Authors' contribution

The present thesis is designed as a cumulative dissertation. In this regard, three scientific articles have been prepared, submitted to peer-reviewed journals, and accepted for publication. According to the local doctoral degree regulations (§ 7 (4), sentence No. 2), significant contributions to the articles from the respective co-authors were acknowledged and finally confirmed by each co-author:

Name Code Affiliation Signature					
Name	Code	Affiliation	Signature		
Fabian Ottawa	FO	University of Potsdam			
Frank Mayer	FM	University of Potsdam			
Pia M. Wippert	PMW	University of Potsdam			
Victor C. Wang	VCW	University of Potsdam			

Study	Design	Data collection	Data analysis	Interpretation	Manuscript
Chap.4.1	VCW , PMW,FM, FO	VCW	VCW	VCW , PMW	VCW , PMW, FM, FO
Chap.4.2	VCW , PMW,FM	VCW	VCW	VCW , PMW	VCW , PMW, FM
Chap.4.3	VCW , PMW,FM	VCW	VCW	VCW , PMW	VCW , PMW, FM

Note: First author is highlighted in bold