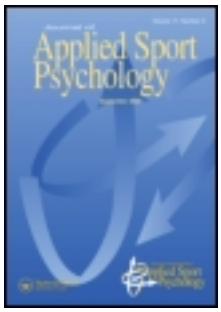

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Psychosocial antecedents of sport injury: Review and critique of the stress and injury model[1]

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Psychosocial Antecedents of Sport Injury: Review and Critique of the Stress and Injury Model[1]

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To counter the narrow scope and atheoretical nature of early research, Andersen and Williams (1988) developed a multi-component theoretical model of stress and injury. The model proposes that athletes with a history of many stressors, personality characteristics that exacerbate the stress response, and few coping resources will, when placed in a stressful situation, be more likely to appraise the situation as stressful and to exhibit greater physiological activation and attentional disruptions. The severity of the resulting stress response is the mechanism proposed to cause the injury risk. The model also proposes interventions for reducing injury risk. For the last decade, this stress-injury model has helped to provide the impetus and theoretical base for much of the psychosocial injury research. The present article examines research support for the different components of the model. The article concludes with suggestions for potential changes to the model and future research needs.

Over the last several decades, researchers have tried to determine if certain psychosocial variables influence vulnerability and resiliency to sport and exercise injuries. Most of the early investigations studied per-

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[1] An earlier chapter by Williams and Roepke (1993) that appeared in the *Handbook on Research in Sport Psychology* and an earlier article by Williams (1996) published in the *International Journal of Stress Management* contributed to the content of the present review and critique of the stress-injury model.

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sonality factors and the stress caused by major life change events, but were minimal in scope and offered no theoretical foundation to explain how these factors might lead to injury. That failure led the present authors in the mid-1980's (Williams & Andersen, 1986; Andersen & Williams, 1988) to develop a multi-component theoretical model of stress and injury. The model proposes that most psychological variables, if they influence injury outcome at all, probably do so through a linkage with stress and a resulting stress response. For the last decade, this stress-injury model has helped to provide the impetus and theoretical base for much of the psychology of sport injury risk research.

In the present article, we describe the stress-injury model and critique the different components of the model based upon what support exists for each component within the research literature. We conclude with suggestions for potential changes in the model and a brief discussion of future research needs. Only minimal attention is given to methodological, measurement, and statistical concerns due to Petrie and Falkstein's coverage of these topics in this special injury issue of *JASP*. Readers may wish to supplement this article with that of Petrie and Falkstein in order to have a better understanding of the research findings and the strengths and weaknesses of past studies.

Stress-Injury Model

According to the original stress-injury model (Andersen & Williams, 1988), when sport participants experience stressful situations such as a demanding practice or crucial competition, their history of stressors (i.e., life event stress, daily hassles, past injury history), personality characteristics (i.e., hardiness, locus of control, sense of coherence, competitive trait anxiety, achievement motivation, sensation seeking), and coping resources (i.e., general coping behaviors, social support, stress management and mental skills, and medication) contribute interactively or in isolation to the stress response. The central hypothesis of the model is that individuals with a history of many stressors, personality characteristics that tend to exacerbate the stress response, and few coping resources will, when placed in a stressful situation, appraise the situation as more stressful and exhibit greater physiological activation and attentional disruptions compared to individuals with the opposite psychosocial profile. The severity of the resulting stress response, caused by the increased stress reactivity of at-risk individuals, is the mechanism proposed to cause the injury risk.

The central core of the model, the stress response, is a bi-directional relationship between the person's cognitive appraisal(s) of a potentially stressful external situation and the physiological and attentional aspects of stress (see Andersen & Williams, 1988, for a detailed diagram of the model, and see Figure 1 for a schematic of the revised model). In terms of sport participation, the individual makes some appraisal of the demands of the practice or competitive situation, the adequacy of his or her ability to meet those demands, and the potential consequences of failure or suc-

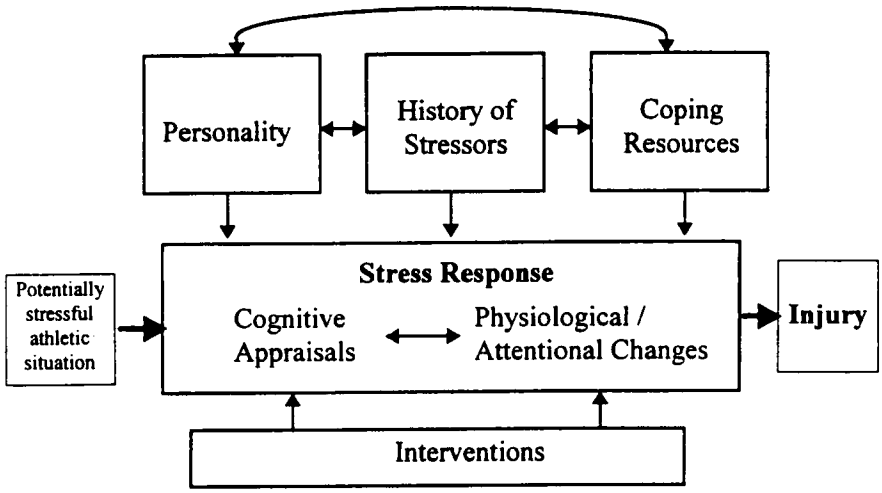

Figure 1. Revised version of the stress and injury model. Note: The original model did not have the bi-directional arrows between personality, history of stressors, and coping resources.

cess. The stress response is more likely to activate and manifest itself physiologically, attentionally, and in the perception of higher state anxiety when an athlete perceives it is important to succeed and inadequate resources exist to meet the demands of the situation. Correspondingly, these cognitive appraisals and physiological and attentional responses to stress constantly modify and re-modify each other. For example, a relaxed body can help diffuse negative cognitions just as anxious thoughts can activate the body through the endocrine and sympathetic nervous system.

Before addressing extant research support for the stress response mechanisms proposed in the model, the question of interest is, "What psychosocial factors influence the stress response?" Above the stress response core of the model are three major areas: personality factors, history of stressors, and coping resources (see Figure 1). These variables may act singly, or in combination, in influencing the stress response and, ultimately, injury occurrence. The original model suggested that an athlete's history of stressors contribute directly to the stress response, whereas personality factors and coping resources act on the stress response either directly or through a moderating influence on the effects of the history of stressors. The presence of desirable personality and/or coping variables may buffer individuals from stress and injury by helping them to perceive fewer situations and events as stressful or by lessening their susceptibility to the effects of their history of stressors. Conversely, the lack of desirable personality characteristics and coping resources, or the presence of undesirable characteristics (e.g., high competitive trait anxiety), may leave individuals vulnerable to higher stress (acute and chronic) and, presumably, greater injury risk.

History of Stressors

This category includes major life events, daily hassles, and previous injury history. Life event stress, hereafter referred to as life stress, has received the most extensive research. Interest in life stress came primarily from the work of Holmes and Rahe (1967), developers of the Social Readjustment Rating Scale (SRRS), and from efforts to test the relationship of life stress to illness. The SRRS is based on the assumption that the experiencing of life events causes the body to adapt and, therefore, leads to stress on the body and an increased risk for illness. Examples of life events include incidents such as the breakup of a relationship, taking a vacation, and death of a loved one. Researchers have supported the relationship of high life stress to illness, and even accidents (e.g., Holmes & Rahe, 1967; Miller, 1988; Sarason, Johnson, & Siegel, 1978; Savery & Wooden, 1994; Stuart & Brown, 1981; Theorell, 1992).

In 1970, Holmes administered the SRRS at the start of the football season to players on the University of Washington football team. He then compared the player's life stress scores (tabulated by determining the life events that occurred during the preceding 12 months) to time-loss injury data monitored by athletic trainers throughout the football season. Holmes found that 50% of the athletes who experienced high life stress during the year prior to the football season incurred a sport injury that required missing at least three days of practice or one game. In contrast, only 9% and 25%, respectively, of athletes with low and moderate levels of life stress experienced equivalent injuries. Holmes concluded that life stress relates to sport injuries in much the same way as it does to the occurrence of illness.

Bramwell, Masuda, Wagner, and Holmes (1975), who conducted the next life stress-sport injury study, modified the SRRS to make it more appropriate to intercollegiate athletes by deleting some of the less applicable stressors and by adding more appropriate ones for college athletes (e.g., academic eligibility difficulties, trouble with the head coach, change in playing status). Results with the modified tool showed an even stronger relationship between life stress and sport injuries. When categorized into low, medium, and high life stress groups, 30%, 50%, and 73%, respectively, of the college football players incurred sport injuries. Using the same tool, Cryan and Alles (1983) replicated the findings with the Pennsylvania State University football team.

In 1983, Passer and Seese advanced the stress-sport injury research by distinguishing between negative and positive life events and by examining personality variables thought to moderate the influence of life stress. Earlier, Sarason et al., (1978) had developed the Life Experiences Survey (LES), a questionnaire that asks respondents to indicate whether they perceive the life event as positive or negative and whether the event has no effect or a little, moderate, or great effect upon them. Sarason et al., hypothesized and found that positive life events had either no effect, or a less detrimental effect, on health-related dependent measures than neg-

ative life events. Passer and Seese used a modified athletic version of the LES and also found that only negative life events was associated with greater risk of injury for football players.

Since Holmes (1970) conducted the first football investigation, at least 30 studies have examined the relationship of life stress to sport injury risk. In a review published in 1993, Williams and Roepke indicated that, 18 of the 20 studies they reviewed found some type of positive relationship between high life stress and injury. The best evidence involved football (six studies), but similar findings occurred across other sports as diverse as Alpine skiing, race walking, figure skating, baseball, gymnastics, soccer, field hockey, wrestling, and track and field. Williams and Roepke reported that injuries tended to occur two to five times more frequently in athletes with high compared to low life stress. In general, the risk of injury increased in direct proportion to the level of life stress. Of the 10 life stress studies conducted since the 1993 review, similar findings occurred for nine of them (Andersen & Williams, 1997; Byrd, 1993; Fawkner, 1995; Kolt & Kirkby, 1996; Meyer, 1995; Perna & McDowell, 1993; Petrie, 1993a, 1993b; Thompson & Morris, 1994), but not for Petrie and Stoever (1994).

The reported strength of the life stress-injury relationship, and whether the injury risk factor was negative life events (NLE), positive life events (PLE), or total life events (TLE), varied considerably across the 30 studies. Although the majority of the studies that distinguished between types of life stress found that only the *negatively* appraised life events (NLE) put athletes at risk for injury (e.g., Byrd, 1993; Meyer, 1995; Passer & Seese, 1983; Petrie, 1992, 1993a; Smith, Ptacek, & Smoll, 1992; Smith, Smoll, & Ptacek, 1990), others found support for TLE and PLE increasing risk of injury. For example, Blackwell and McCullagh (1990) found that TLE stress contributed the most to injury occurrence and PLE stress the most to the likelihood of receiving a severe injury. Hanson, McCullagh, and Tonymon (1992) found that only PLE stress helped to differentiate among injury frequency groups, and Petrie (1993b) found that PLE was the only life event stressor to predict time loss due to injury. Petrie (1993b) suggested that the life events that athletes might initially rate as positive (e.g., major change in level of responsibility on team, receiving an athletic scholarship) may, in the future, produce considerable stress by putting more pressure on the athlete to perform well or to feel responsible for the team's performance. These changes are likely to lead to negative cognitive appraisal of sport situations, and thereby, a greater risk for injury.

Hardy and Riehl (1988) found that injured athletes, overall, had significantly higher NLE than noninjured athletes, but that injured female athletes reported higher scores on TLE compared to uninjured female athletes. Both TLE and NLE significantly predicted injury across sports, but analyses within sports indicated that injured softball players reported significantly higher TLE, baseball players higher NLE, and track athletes higher object loss (OL; loss of a significant other through death, divorce,

separation) compared to equivalent uninjured players. Except for track, none of the stress measures predicted injuries in the specific sports. In track, both TLE and OL predicted injuries. These findings led Hardy and Riehl to conclude that the life stress injury relationship is influenced by both the athlete's sex and the sport. Hardy, O'Connor, and Geisler's (1990) study of Division I soccer players also supported the conclusion that gender affects the relationship between life stress and injury. See Petrie and Falkstein's article (this issue) for a more comprehensive discussion of the influence of gender and sport on the stress-injury findings.

The preceding differences aside, 27 of the 30 studies that assessed life events found at least some significant relationship between life stress and injury. This almost universal finding is compelling, especially considering it occurred across sports and competitive levels (youth to elite level), and with diverse measures of life stress and definitions of injury. Researchers used eight questionnaires to assess life stress and the criteria for injury varied from receiving treatment from an athletic trainer that required no need to reduce practice time or modify activity (e.g., Blackwell & McCullagh, 1990) to receiving treatment that required missing more than a week of practice (e.g., Coddington & Troxell, 1980). These different operational definitions make it difficult to determine relative injury risk across sports and competitive levels and across positive versus negative stressors. Diverse operational definitions also contributed to the difficulty in determining the effect of life stress on severity of injury. Approximately two-thirds of the studies found some relationship between life stress and injury severity (Blackwell & McCullagh, 1990; Hanson et al., 1992; Hardy et al., 1990; Hardy & Riehl, 1988; Kerr & Minden, 1988; Meyer, 1995; Petrie, 1992, 1993a) and one third found no effect (Cryan & Alles, 1983; Hardy, Richman, & Rosenfeld, 1991; Lysens, Vanden Auweele, & Ostyn, 1986; Williams, Tonymon, & Wadsworth, 1986).

The history of stressors portion of the model also includes daily hassles. The stress from many minor daily problems, irritations, or changes may contribute to stress levels and injury risk every bit as much as that encountered from major life event changes. Kanner, Coyne, Schaefer, and Lazarus (1981) suggested that one way major life events influence illness outcome is through all the minor hassles that accompany a major life event. For example, moving to a new city possibly involves loneliness, trying to adjust to a new climate, finding one's way around, and so forth. Such low grade wear and tear, as a result of a major event, may be what increases vulnerability. Initial research efforts failed to support daily hassles as a contributor to injury risk (Blackwell & McCullagh, 1990; Hanson et al., 1992; Meyer, 1995; Smith et al., 1990), but the studies had methodological problems that prevented reaching a definitive conclusion. Each measured daily hassles at only one time, either at the start or near the end of the season. Because of their ever-changing nature, daily hassles need frequent assessment throughout the athletic season. Researchers can then compare subsequent injuries to the immediately preceding score for stress from minor daily problems/hassles.

In a recent unpublished master's thesis, Fawkner (1995) employed such a design (i.e., assessed hassles on a weekly basis) and found that athletes were more likely to incur an injury when they experienced significant increases in daily hassles in the week before and week of injury. Byrd (1993), in another master's thesis, found modest support for a relationship between daily hassles and injury. Daily hassles predicted number of injuries in basketball (accounted for 13.1% of the variance), but not volleyball; nor did they predict days lost or modified due to injury. Although Byrd took monthly assessments of daily hassles, it appears as though the regression analysis included only the initial measure. The correlations conducted between the four monthly measures of hassles and the injuries for the following month indicated only a significant correlation between the pre-season measure and the injuries during the first month. Fawkner's findings suggest that assessing changes in hassles on a weekly basis and noting increases in hassles may yield a more relevant measure of stress and risk for injury. Either way, these two studies offer some support for including daily hassles as an injury vulnerability factor.

Previous injuries, the third component under history of stressors, was included in the stress-injury model for a number of reasons. If the athlete has not recovered enough to return to the sport, but does anyway, the probability of reinjury is high. Also, if the athlete is physically, but not psychologically prepared to return to sport participation, problems may arise due to anxiety and negative cognitive appraisals. For example, Andersen and Williams (1988) conjectured in their initial stress-injury model paper that fear of reinjury may lead to a considerable stress response and, thereby, increase the probability of reinjury. Few researchers have examined the relationship of previous injury history to subsequent injury risk. Hanson et al., (1992) found that time since injury recovery was not related to frequency or severity of injury occurrence, but Lysens et al., (1984) found that physical education students with a prior history of injury were at high risk of recurrence. In the future, any examination of prior injury as a risk factor should consider whether the athlete had fully recovered physically. If the athlete has not, then risk for reinjury probably constitutes more a physical vulnerability to injury factor than a psychological risk factor.

Personality

Of the six personality variables proposed in the initial presentation of the stress-injury model, no injury researchers assessed hardiness, sense of coherence, and achievement motivation. Mixed results occurred when researchers examined locus of control, trait anxiety, and sensation seeking. Pargman and Lunt (1989) reported that a higher injury rate correlated with an external locus of control in a sample of freshman college football players. In contrast, Kolt and Kirkby (1996) found no relationship in nonelite gymnasts, but a more internal locus of control significantly predicted injury in elite gymnasts. The other researchers who used nonsport measures to assess locus of control (Blackwell & McCullagh, 1990; Han-

son et al., 1992; Kerr & Minden, 1988; McLeod & Kirkby, 1995) and trait anxiety (Kerr & Minden, 1988; Lysens et al., 1986; Passer & Seese, 1983) found no relationship between these variables and the incidence of injury. When researchers used sport versus general measures, athletes who scored high on either external locus of control (Dalhauser & Thomas, 1979) or competitive trait anxiety (Blackwell & McCullagh, 1990; Hanson et al., 1992; Passer & Seese, 1983; Petrie, 1993b) incurred more injuries or more severe injuries.

In Petrie's (1993b) study, the finding occurred for football starters, but not non-starters. Petrie also found that competitive trait anxiety moderated the effects of positive life stress such that higher levels of anxiety and stress were associated with more days missed due to injury. He conjectured that the combination of starting and having high life stress and competitive trait anxiety "may have negatively influenced these athletes' appraisals such that they either viewed practices and competitions as threatening/uncontrollable or believed they did not have the resources to cope. Such appraisals may have corresponded with attentional and physiological disruptions that would have increased the starters' vulnerability to injury" (p. 272).

Unfortunately, except for Petrie (1993b), the preceding studies either did not use statistics or did not employ designs that permitted testing whether personality variables might interact with history of stressors or with other personality and coping variables in influencing injury risk. Such limited designs and analyses will not elucidate the potential complexity of the relationship of personality factors to injury vulnerability and resiliency. This limitation, and the equivocal preceding findings, indicates the need for more research into the relationship of locus of control and trait anxiety to injury vulnerability. It also appears that sport-specific instruments might yield more fruitful findings than general instruments.

In addition, when examining competitive trait anxiety, researchers may want to consider using a questionnaire such as the Sport Anxiety Scale (SAS) developed by Smith, Smoll, and Schutz (1990) rather than the Sport Competition Anxiety Test (SCAT) used by previous researchers. The SCAT employs a unidimensional measure of anxiety, whereas the SAS distinguishes between cognitive and somatic trait anxiety. Different levels of these subtypes of anxiety may differentially influence cognitive appraisal and attentional/physiological disruptions when in a stressful practice or competitive situation. Contemporary anxiety researchers (e.g., Jones, 1995) also recommend assessing not just the intensity of anxiety symptoms (e.g., SCAT, SAS), but whether athletes interpret their anxiety symptoms as having a facilitative or debilitative effect on performance (direction of anxiety). Athletes who have high anxiety and who interpret it as having a detrimental effect on performance may be the most at risk for incurring an injury. See Jones for a more thorough discussion of the conceptual distinction between intensity and direction of anxiety, and for suggestions to modify current anxiety tools.

Only one study (Smith et al., 1992) examined the role sensation seeking

plays in injury risk, and its design serves as an excellent prototype for the type of studies needed in future personality research. According to Zuckerman (1979), sensation seeking represents a biologically based dispositional variable that reflects individual differences in optimal levels of arousal. Compared to high sensation seekers, sensation avoiders have a lower tolerance for arousal and, therefore, do not care for change, avoid the unfamiliar, and stay away from risky activities. Smith et al., found that only athletes who scored low in sensation seeking had a significant positive relationship between major negative sport-specific life events and subsequent injury time-loss. They found no support for a competing hypothesis that the characteristics of high sensation seeking (e.g., more risk-taking behaviors) would constitute an injury vulnerability factor. Also, although they found that sensation avoiders reported poorer stress management coping skills, no support existed for differences in coping skills mediating the injury vulnerability differences.

Andersen and Williams (1988) proposed that the personality factors identified in the stress-injury model were merely suggestions for initial research rather than an exhaustive list of potential factors. Recent findings with personality related factors not included in the original model paper indicate merit for the inclusion of other personality factors in future injury research. For example, Williams, Hogan, and Andersen (1993) found that intercollegiate football, volleyball, and cross-country athletes who experienced positive states of mind (e.g., ability to stay focused, keep relaxed, share with others) early in the season incurred significantly fewer injuries during their athletic season compared to athletes who had less positive states of mind. Even stronger findings might have resulted had they taken multiple assessments for positive states of mind and then compared subsequent injury rates to the immediately preceding positive states of mind measurement.

Just as positive states of mind might buffer the effects of potentially stressful sport situations, thereby creating less stress and fewer injuries, the presence of negative mood states (e.g., anxiety, anger) might do the opposite. Fawkner (1995) found such a relationship when she assessed team and individual sport athletes' mood states (five negative and one positive) over the course of the competitive season. She noted significant increases in mood disturbance in the measurement immediately prior to injury.

In other promising personality research studies, aggression and anger were found to be related to injury risk. Fields, Delaney, and Hinkle (1990) found that runners scoring high (e.g., more aggressive, hard-driving) on a Type A behavior screening questionnaire experienced significantly more injuries, especially multiple injuries, compared to runners scoring lower on this measure. Personality data from Thompson and Morris (1994) indicates that high anger directed outward, but not inward, increased injury risk. In a related personality study, Wittig and Schurr (1994) found that being "tough-minded" (i.e., more assertive, independent, and self-assured) predicted the likelihood of more severe injuries, but not the oc-

currence of injury. They conjectured that an athlete with this type of personality profile might take greater risks and, therefore, incur more severe injuries.

Other personality researchers examined defensive pessimism and obtained mixed results. Perna and McDowell (1993) found that athletes who scored high on defensive pessimism, and who also experienced a high degree of life stress, experienced more illness/injury symptoms than did athletes scoring low on defensive pessimism and having fewer stressful life events. Of equal interest is their finding that athletes with a defensive pessimist profile took fewer rest days, especially under the high stress conditions, than did optimists even though the pessimists experienced more illness and injury symptoms. Meyer (1995), however, in a similar study did not replicate their results.

Coping Resources

The stress-injury model includes coping resources consisting of social support, stress management and other psychological coping skills, general coping behaviors such as good sleeping patterns and nutritional habits, and medication (self or prescribed). Considerable evidence exists for an athlete's coping resources either directly affecting injury outcome or moderating the influence life stress has on injury vulnerability.

Williams, Tonymon, and Wadsworth (1986) found that the only predictor of injury among intercollegiate volleyball players was a low level of coping resources. Their measurement consisted of a rather simplistic, but easy to administer, global measure that included items assessing social support and general coping resources such as eating and sleeping behaviors and taking time for self (Miller & Smith, 1982). Blackwell and McCullagh (1990) did not replicate the Williams et al., findings when they used the same coping resources questionnaire with intercollegiate football players. When Hanson et al., (1992) used a modification of the questionnaire (made it more appropriate for an athlete population), they found that coping resources contributed the most in discriminating group differences in both severity and frequency of injuries . Their injury groups had significantly fewer coping resources compared to the no injury group.

Other researchers examined social support alone or separately assessed social support and psychological coping skills. Social support directly influenced sport injuries in three studies (Byrd, 1993; Hardy et al., 1990; Hardy, Prentice, Kirsanoff, Richman, & Rosenfeld, 1987). Athletes with high levels of social support had a lower incidence of injury, and those with low levels of social support had more injuries, regardless of life stress. These findings occurred only for males in the Hardy et al., (1990) study. Social support moderated the life stress-injury relationship in other studies, but not always in the direction hypothesized by the stress-injury model. Studying female collegiate gymnasts, Petrie (1992) found that for gymnasts with low social support (bottom third scores on a measure of social support satisfaction), negative life stress accounted for 14 to 24% of the variance in minor, severe, and total injuries. No significant rela-

tionships between life stress and injury outcome occurred within any of the gymnasts in the high social support groups. Petrie did not report statistics on whether social support directly influenced injury outcome. He proposed that social support, depending upon the level, appears to function in two substantially different ways when athletes experience high negative life stress. High social support seems to protect the athletes from injury, but low social support appears to exacerbate the deleterious effects of life stress such that vulnerability to injury is increased significantly.

In a subsequent study, Petrie (1993a) found that playing status moderated the social support-life stress injury relationship. No relationship emerged for non-starters but, for football starters, more severe injuries, greater time loss, and more games missed occurred for players with high negative life stress and low social support. These findings replicated Petrie's 1992 findings and support the hypothesized relationship in the stress-injury model. Contrary to the 1992 study and the injury model, however, he also found that under conditions of lower stress, starters who reported high levels of social support were more likely to experience injury than those reporting low levels of support. As a possible explanation for this unexpected finding, he suggested that under conditions of lower stress, high social support may provide athletes with a greater sense of security and confidence. These, in turn, could translate into an increase in sport risk-taking behaviors and greater injury vulnerability.

In their 1991 study, Hardy and his colleagues found that high social support, when combined with major object losses or many positive life events, had a negative rather than positive effect on the well-being of male athletes. In contrast, for male athletes with high negative life events, injury rates decreased when the number of social support providers and the degree of fulfillment for emotional challenge support increased. The researchers concluded that social support was effective with the male athletes only to the degree that a match exists between the stressor and the support type. Hardy et al., (1991) also studied female athletes, but found no relationship between social support and injury frequency and severity.

Recently, Andersen and Williams (1997) found an injury outcome linkage between social support and stress responsivity. They examined the influence of life stress, social support, and stress responsivity (e.g., peripheral narrowing during stress) on injury outcome. For the entire sample of collegiate athletes, only negative life stress predicted injury outcome. Thus, it appeared that social support did not have a direct relationship to injury. When the sample was divided into participants with high and low social support (upper and lower 33%), and these groups were analyzed separately, life stress was again the only variable significantly related to injury outcome for those with high social support. For participants with low social support, however, life stress combined with a measure of stress responsivity (i.e., peripheral narrowing during stress) together significantly accounted for 26% of injury variance. These results indicate that low levels of social support may directly influence the stress response

and act in addition to life stress, leading to greater peripheral narrowing, and thus, greater likelihood of injury.

A major methodological advance occurred when Smith et al., (1990) studied life stress and two coping resources and then used analyses to determine how the two moderators might interact with one another and life stress to increase or decrease vulnerability to injury. Their two coping resources included social support and psychological coping skills (e.g., the ability to think clearly under stress and to control arousal and concentration). The authors proposed a distinction between conjunctive moderation, in which multiple moderators must co-occur in a specific combination or pattern in order to maximize a relationship between a predictor (e.g., life events) and an outcome variable (some aspect of injury outcome), and disjunctive moderation, in which any one of a number of moderators contributes individually to the predictor-criterion relationship.

Smith et al., (1990) found that coping resources moderated the life stress-injury relationship, but did not directly affect injury occurrence. Athletes scoring low in *both* social support and psychological coping skills exhibited the strongest correlation between major negative life events and subsequent injuries. For athletes who scored in the bottom third on both coping resource tools, negative life events (high) accounted for 22% of the injury time loss variance. The injury variance from life stress increased to more than 30% when comparing more extreme (lower quartile) social support and coping skills athletes. All groups having moderate to high levels of social support or psychological coping skills exhibited non significant relations between life stress and injury. The results for athletes with high stress-low coping resources suggest that social support and psychological coping skills operate in a conjunctive manner (need low scores on both) to reduce the injury risk of athletes with high negative life events. In contrast, for athletes with moderate or high scores on social support or psychological coping skills, disjunctive moderation led to non significant relations between life stress and injury. That is, having either of the psychological assets reduced injury vulnerability.

The Smith et al., (1990) study provides an excellent prototype for future injury research. Unfortunately, no other researchers have employed a similar design and analyses, perhaps because of the requirement for a large number of participants (e.g., Smith et al., studied 451 high school varsity athletes). In two other studies that examined psychological coping skills (Byrd, 1993; Petrie, 1993b), no relationship was found to injury outcome. The inability to replicate the Smith et al., findings is not surprising considering the differences in design and analyses among the studies. Byrd's study assessed only a direct relationship to injury vulnerability. Although Petrie used regression models that tested for both direct and interaction effects, Smith et al., offered a compelling argument for why this type of analysis might mask significant results.

Injury researchers may not know exactly how coping resources affect injury vulnerability, but the preponderance of evidence clearly supports the conclusion that coping resources (particularly social support) directly

affect injury outcome, moderate the life stress-injury relationship, or do both. More research is needed, particularly research that examines psychological coping skills and the potential conjunctive or disjunctive effects of multiple coping resources.

The Stress Response

Few researchers have tested the mechanisms proposed to explain how psychosocial factors influence the likelihood of injury. An elevated stress response, particularly increased muscle tension, narrowing of the visual field, and increased distractibility, is what Andersen and Williams (1988) hypothesized places individuals at greater risk for injuries. With one exception (Andersen & Williams, 1997), none of the studies of the stress response examined the relationship of stress reactivity to injury outcome. Instead, they examined the prediction of what should occur under low and high stress conditions to state anxiety, peripheral narrowing, central vision distractibility, and/or muscle tension for individuals with high, compared to low, injury risk profiles.

Only one study examined the connection between psychosocial factors and muscle tension under low and high stress conditions (Andersen, 1988). That study found increased muscle tension during the stress condition for the total group, but failed to support the model's hypothesis of even greater muscle tension for high risk individuals. The failure to do so may have resulted from Andersen studying the general population rather than a high risk subpopulation.

When they compared performance under stressful and non-stressful laboratory conditions, Williams, Tonymon, and Andersen (1990, 1991) found that recreational athletes who had experienced many major life events during the preceding year reported higher state anxiety and greater peripheral vision narrowing during the high stress condition compared to athletes who had experienced few major life events. The high stress condition consisted of simultaneously performing a peripheral vision task and a Stroop color word task positioned in the central field of focus while listening to a tape that fed loud distracting phrases into the left ear and white noise and Stroop color words into the right ear. During the low stress condition, the participants stayed in a quiet environment and performed only the peripheral vision task. A third study (Andersen, 1988) used a similar stress manipulation and found that the stress condition peripheral narrowing for participants with high life stress became even greater when the experimenter moved the peripheral targets in slightly faster than the initial assessment. In previous studies, the experimenter moved the targets in quite slowly in order to eliminate any reaction time contaminate. In real life situations, objects (e.g., people, balls) often come in from the periphery at very fast speeds, suggesting considerably greater deficits than those found in any of the laboratory studies.

The second Williams et al., study (1991) assessed the effects of coping resources (social support and general coping behaviors such as diet, nutrition, and time for self) and daily hassles in addition to the effects of

life events. Coping resources did not affect stress reactivity directly, but moderated some of the history of stressor effects. Recreational athletes with high negative life events or daily hassles, but who also had high coping resources, experienced less state anxiety during the stress condition compared to similar athletes with similar high stress, but low coping resources. Coping resources, however, had no significant effect on peripheral narrowing.

In a recent study, Williams and Andersen (1997) were the first to determine whether athletes with high injury risk profiles experience greater distractibility in the central field of vision in addition to their peripheral narrowing when they perform under stressful conditions. Their measures of central vision deficits included missing or delayed response to important visual cues, responding to irrelevant cues, and lowering of perceptual sensitivity (d', a ratio of missing cues and reporting cues not present). They found that performance in the high compared to low stress condition led to significant deterioration on all the perceptual variables, but athletes with high negative life event scores experienced even slower central vision reaction time and greater peripheral narrowing than athletes with low life event stress. In addition, males with low versus high social support failed twice as often to detect central cues, whereas males with high negative life events, low social support, and low coping skills had the lowest perceptual sensitivity. For females, only one significant central vision deficit occurred. Females with high versus low negative life events had twice as many failures to detect central cues, but a significant interaction indicated that this failure occurred only with the group of females with high life stress who had low psychological coping skills.

None of the preceding studies tested the relationship of stress reactivity to injury outcome. In a recent study, however, Andersen and Williams (1997) gathered relevant psychosocial data, tested their athletes' central and peripheral vision during high and low stress conditions, and then recorded their frequency of injuries for the following season. For the entire sample of athletes, only negative life events significantly accounted for variance in injury frequency (19%), but for athletes with low social support, negative life events coupled with changes in peripheral narrowing accounted for 26% of the variance in injury frequency. Low social support athletes with more negative life events and greater peripheral narrowing during stress were more likely to incur injuries than low social support athletes with few negative life events and less peripheral narrowing during stress. Although modest, this study did connect the suggested mechanisms proposed in the Andersen and Williams (1988) model to actual injury outcome.

A completely different paradigm offers additional support for attentional disruptions mediating the stress-injury relationship. The Thompson and Morris (1994) study cited earlier also determined whether the relationship of stressful life events to injury is mediated by impaired attention, either vigilant (broad, external) or focused (narrow, internal). Using the Symbol Digit Modalities test, they found that injury risk was elevated

when recent life event stressors were present and when vigilance decreased, suggesting that stressful life events elevate injury risk by reducing vigilance. In addition, as the players' ability to focus attention increased, their likelihood of injury decreased significantly.

Interventions to Reduce Injury Vulnerability

The least researched area in the stress-injury model is the implementation and assessment of interventions that might lessen the stress response and reduce injury vulnerability. The model suggests a two-pronged approach to prevent injuries caused by high stress (see Figure 1). One set of interventions aims to change the cognitive appraisal of potentially stressful events and the second set of interventions deals with modifying the physiological/attentional aspects of the stress response. See Durso-Cupal's (1998) article in this issue for a discussion of the specific psychological interventions for preventing sport injuries.

Partial support for the interventions portion of the model comes from a study in which DeWitt (1980) found that her basketball and football players detected a noticeable decrease in minor injuries after participation in a cognitive and physiological (biofeedback) training program. Unfortunately, DeWitt gathered no objective data regarding physical injuries.

Davis (1991) reported on an archival review of injury data collected by athletic trainers before and after two university teams practiced progressive relaxation and technique/strategy imagery during team workouts. Major findings included a 52% reduction in injuries for swimmers and a 33% reduction in injuries for football players during the athletic season in which they practiced relaxation and imagery skills. The injury benefits from these two intervention programs are even more impressive considering that both programs targeted athletes in general rather than athletes at risk, and neither program included cognitive or concentration training interventions. These results suggest that sport psychologists who initiate performance enhancement programs should include assessment of possible injury reduction benefits in addition to assessing improvement in performance.

A recent prospective injury prevention study conducted by Kerr and Goss (1996) offers some support for reducing stress and injuries through a stress management program. The participants included 24 gymnasts who competed on the national and international level. The participants in the control group and the experimental group were matched according to sex, age, and performance. Across an eight month time period, each experimental gymnast met individually with one of the experimenters for 16 one-hour bi-weekly stress management sessions. Meichenbaum's stress inoculation training, which included skills such as cognitive restructuring, thought control, imagery, and simulations, provided the framework for the stress management program,

From mid-season (four months after pre-intervention assessment) to peak season (four months from mid-season and held at the National Championships), the stress management group reported significantly less

negative athletic stress and total negative stress and a trend toward more positive athletic stress compared to the controls. No differences existed at mid-season (after the first four months). Although not statistically significant, from mid-season to the National Championships the stress management participants had about half the injury incidence scores of the participants in the control group. When discussing why the injury data did not reach significance, the experimenters speculated that introducing relaxation and distraction control skills not until the fourth month may have meant that the gymnasts did not have the specific skills to cope with increased arousal and distractions soon enough to have an impact on injuries. The effect size for injury, however, was substantial (i.e., Cohen's $d = .67$, in the high medium effect size range), and the reason the difference was not significant probably had much more to do with the small number of participants in each group and the resultant low power than the effectiveness of the intervention (see the Andersen and Stoove [1998] in this issue). Thus, both the reduction in stress and the injury prevention results of the Kerr and Goss study are quite encouraging.

The results of the earlier injury studies that examined social support variables suggest that resiliency to sport injuries might increase with interventions designed to increase social support in athletes. An article by Richman, Hardy, Rosenfeld, and Callahan (1989) is an excellent source for a variety of social support/team building strategies that coaches and sport psychologists could implement to affect the type and level of social support for athletes. To date, no researchers have tried to decrease stress or injuries by improving social support.

Suggested Modifications for the Stress-Injury Model

Considering the substantial support that exists for the different facets of the model and for the model's hypotheses, no major changes in the model appear warranted. Some minor changes (see Figure 1) and some words of caution do, however, seem warranted. The model, as it stands, with its central core of situational acute stress responsivity, is probably most appropriate for acute injuries. For some other types of injuries, such as overuse injuries, the causes and the mechanisms are already known. Overuse injuries result from *overuse* and probably are not, or only minimally, mediated by mechanisms within the stress response. *Why* athletes overuse joints and muscle systems is another matter. Meyer (1995) has suggested that some personality traits may influence overuse injury outcome (e.g., perfectionism). Other chronic injuries, however, may come about through low grade stress responsivity. In acute high stress responses, all the attentional and physiological symptoms in the Andersen and Williams (1988) model may become manifest. In low grade stress, possibly only generalized muscle tension is present. Some chronic injuries may result from exercising with low level antagonistic and agonistic muscles being simultaneously active leading to undue strain on muscles and joints. Low grade stress, with its concomitant endocrine changes, may also have a negative effect on recovery from bouts of intense exercise,

leaving muscles and joints not quite ready for another intense exercise session. This possibility of the development of chronic injuries through low level stress responsivity has yet to be explored.

For the personality section of the model, several of the variables (i.e., hardiness, sense of coherence, achievement motivation) have not received attention, nor does it seem likely that they will. More fruitful personality directions might occur from pursuing some of the new variables identified in injury research since the development of the model (see the earlier Personality section). The recent work by Williams et al., (1993) and Fawkner (1995) suggests that some of the personality variables that recently have been linked with injury outcome (e.g., negative mood states, absence of positive states of mind) also seem intimately tied to coping resources. For example, if athletes experience a positive mood state or have a positive state of mind, then it might follow that they could better use their coping resources when dealing with stressful situations. Conversely, if they had poor cognitive and somatic coping skills, then stressful situations could lead to negative mood and negative states of mind. Thus, we have modified the model to include a bi-directional arrow between personality and coping resources (see Figure 1). Future researchers may wish to examine the interplay between personality and coping resources and how they individually, or interactively, contribute to stress responsivity, and ultimately, injury outcome.

We also propose adding bi-directional arrows between personality and history of stressors and between coping resources and history of stressors because the stressors (i.e., major life events, hassles, previous injury) people experience do affect how they develop and characteristically respond to self and others. The most dramatic example of this would be post-traumatic stress disorder (American Psychiatric Association, 1994). The field of rehabilitation psychology also offers plenty of evidence for personality change following injurious events. For example, some individuals who have experienced an amputation or severe burn or a spinal cord injury begin to become more withdrawn, agoraphobic, depressed, and sometimes suicidal (e.g., Kishi, Robinson, & Forrester, 1994). Other major life events, such as having a loved one with cancer, can increase general anxiety and depression plus influence coping (Compas, Worsham, Ey, & Howell, 1996). The proposal of the new bi-directional arrows to the model also is consistent with the transactionist point of view currently espoused for better understanding in the area of coping (e.g., Aldwin, 1994).

Under the coping resources section of the model, the medication variable presents some problems. If athletes are self-medicating and using stimulants for competition, then the connection to the stress response and possible injury is obvious. Unfortunately, researching the medication histories and practices of athletes poses too many problems (e.g., too few athletes taking the relevant drugs, truthful reporting, the clandestine nature of some drug taking) for researchers to be confident in their results. Removal of this item from the model at this time seems warranted.

In the stress response section of the model, the peripheral narrowing and distractibility variables should be expanded to include audition. Landers, Wang, and Courtet (1985) showed that deficits in audition occur under high stress conditions in the sport of shooting. Shooters took significantly longer to respond to auditory cues when stressed. Although longer response times or failure to respond to auditory cues has little to do with injury for shooters, in other sports (e.g., contact sports), not responding or responding slowly to auditory warnings of danger could have serious implications for injury risk. Thus, we believe there is merit in expanding the model, and the research, into the area of auditory detection during stress.

Summary and Future Research Recommendations

In summary, the complex, interactional stress-injury model proposed by Andersen and Williams (1988) has proven a viable theoretical foundation for conducting research on psychology of injury risk. Future researchers need to study multiple predictor and moderator variables and then determine the varying patterns by which these variables interact with one another to affect the hypothesized stress response and injury vulnerability and resiliency. Although support exists for the risk factors influencing the mechanisms proposed in the model, particularly peripheral narrowing, more research is needed to determine if experiencing the different perceptual and physiological aspects of the stress response influence the occurrence of injury. Researchers also may want to consider simultaneously examining the array of non-psychological and psychosocial risk factors in order to help determine the relative contribution of psychosocial factors to injury compared to non-psychological factors.

Perhaps the most exciting future research, however, will come from implementing and testing the effectiveness of interventions aimed at modifying the psychosocial risk factors and reducing stress reactivity. If researchers find that interventions such as stress management do lower injury risk, they might want to explore the mechanisms by which such interventions are effective. For example, do athletes who undergo stress management interventions show a lower stress responsivity (e.g., less peripheral narrowing, less disruption in the central field of vision, less muscle tension) in the laboratory after treatment compared to pretreatment. Only through such empirical efforts as the preceding will knowledge grow regarding the relationship of psychosocial factors to injury vulnerability and the role that interventions might play in reducing the cost and trauma of potentially avoidable injuries.

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