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**Message from the Director**

It is with great pride that I introduce this outstanding collection of articles from the 2013-14 participants of the MU McNair Scholars Program. The papers presented here represent the culmination of a year’s worth of research and scholarly activity. They reflect the energy, creativity and effort of the scholars, themselves, as well as the careful guidance, support and diligence of their faculty mentors. Six very diverse topics are explored and reported in their entirety within this interdisciplinary journal. While their subject matter and journalistic styles may differ, they, along with the other McNair Scholars listed in this publication, are to be commended for their persistence and dedication to this rigorous undergraduate research experience that will benefit them greatly in their pursuits of graduate studies.

Since 1989, the McNair Program has been a University-wide effort that continues to attract students and faculty mentors from a variety of academic departments and fields of inquiry. Students have had the opportunity to learn about the importance of earning an advanced degree, while gaining the skills and tools that will guide them through their future academic journeys. The program proudly bears the name of astronaut and scientist, Dr. Ronald E. McNair, who died in the Challenger explosion in 1986. His accomplishments and high standards set an outstanding example for these developing scholars.

I am truly honored to be associated with an initiative such as this. So many faculty, staff and administrative members of the MU community have worked to ensure a supportive and cohesive environment that prepares these exceptional students for graduate programs. We are proud to highlight the work of these talented young researchers, in this, the twentieth edition of the *MU McNair Journal*. Our best wishes go out to all of them as they continue to move along their scholastic continuum.

NaTashua Davis, PhD
Director
McNair Scholars Program

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**The McNair Scholars Program**

**BACKGROUND**

College students who are considering study beyond the baccalaureate level realize their dreams through the McNair Scholars Program at the University of Missouri-Columbia (MU). MU was one of the original fourteen universities selected to develop a program established by the U.S. Department of Education and named for astronaut and Challenger crew member Ronald E. McNair. The purpose of the program is to provide enriching experiences that prepare eligible students for doctoral study.

**PROGRAM ELEMENTS**

One of the most exciting aspects of the McNair Scholars Program is the opportunity for junior or senior undergraduate students to participate in research experiences. McNair Scholars receive stipends to conduct research and engage in other scholarly activities with faculty mentors from the areas in which they hope to pursue graduate study. These research internships are either for the academic year or for the summer session and are under the supervision of faculty mentors. For academic year internships, students work a minimum of ten hours per week during the fall and winter semesters. Summer interns work full-time for eight weeks.

McNair Scholars also attend professional conferences with their mentors, go to graduate school fairs, prepare for graduate school entrance exams, receive guidance through the graduate school application process and obtain information on securing fellowships, graduate assistantships, and loans. Participants learn about graduate school life, advanced library skills, and effective ways to present their work. At the completion of the research internships at MU, McNair Scholars make formal presentations of their research to faculty and peers at the McNair Scholars Conference and submit papers summarizing their work. Students who participated as juniors the previous year continue in the program during their senior year for graduate school placement and to further develop their skills.

**ELIGIBILITY**

Participants must meet grade point average standards; be U.S. citizens or permanent residents; and qualify as either a first generation college student with an income level established by the U.S. Department of Education, or a member of a group that is underrepresented in graduate education.

All students who wish to be involved submit an application to the program. A committee composed of faculty members and representatives from both the graduate dean’s office and the McNair Scholars Program selects participants and approves faculty mentors. Research internships are offered to those students who are juniors or seniors and are identified as having the greatest potential for pursuing doctoral studies.
Larval Fish Assemblages of the Free Flowing Gasconade River and the Regulated Osage River, Two Tributaries of the Lower Missouri River, USA

JOSEY RIDGWAY
Craig Paukert PhD, Mentor
Department of Fisheries and Wildlife Sciences

Josey Ridgway is from Warrenton, Missouri and was a Fisheries and Wildlife Sciences major. As an undergraduate he worked for the Missouri Cooperative Fish and Wildlife Research Unit and has been an active member of the Mizzou Fisheries and Aquatic Sciences Society.

This fall, Josey will begin his graduate research assistantship at Tennessee Technical University studying Asian Carp Sampling protocols in the Tennessee and Cumberland rivers. Josey plans on becoming a fisheries ecologist working on large rivers and their tributaries.

ABSTRACT
River regulation has altered flows and temperatures which may affect native fish reproduction. We compared larval fish assemblages in a free flowing and regulated tributary of the Lower Missouri River. Drift net larval sampling was conducted weekly from March 20 to July 3, 2013 at one transect 14.5 river kilometers (rkm) from the Missouri River confluence in the Osage River and 3.2 rkm from the Missouri River confluence in the Gasconade River. Regulation in the Osage River may have increased the contribution of reservoir species and limited the reproduction of species that depend on natural discharge and temperature (i.e., catostomids and percids). The three most abundant families from the Osage River (i.e., centrarchids, clupeids, and percids) exhibited maximum CPUE on the same day when the Osage River experienced its lowest discharge (314 cms) and oddly when the Gasconade River was at its greatest discharge (640 cms). Clupeids (gizzard shad Dorosoma cepedianum) in the Osage River had the greatest CPUE of any family (65,049 fish/m$^3$) and contributed 64 times the second most contributed family, percids. Our results suggest river regulation may affect the timing and abundance of larval fishes, but this relationship may differ by taxa.

KEY WORDS larval fish, river regulation, hydroelectric dam, channelization, hypolimnetic release

INTRODUCTION
Rivers, tributaries, and their flood plains are often altered and regulated by dams, levees, and channeling for a variety of human activities (e.g., power generation, agriculture, consumption, recreation, and boat passage). In the USA, approximately 98% of rivers have been altered in various intensities disrupting ecological processes (Lytle & Poff 2004). Instead of naturally flowing in response to precipitation events, rivers with hydroelectric dams and impoundments often limit the frequency and magnitude of peak and low discharge events (Petts 1986). Discharge is the master variable governing the abiotic structure (i.e., water temperature, channel geomorphology, and habitat) of the riverine environment, and consequently the abundance (Poff et al. 1997), composition, and diversity of biota (Karr 1981). In addition, hydroelectric dams alter the thermal regime by discharging water from beneath the upstream reservoir thermocline known as hypolimnetic releasing. Through evolutionary time, riverine fishes have evolved traits to occur in their natural environment and are triggered to spawn during specific discharge and thermal events (Craven et al. 2010; Olden & Naiman 2010; Lytle & Poff, 2004). Therefore, rivers with large hydroelectric dams have the potential to reduce fish growth, reproduction, and recruitment, and ultimately shift fish communities (Dallas 2008).

Larval fish provide the first key evidence of successful reproduction. Therefore, assessing larval fish assemblages can h
help delineate the potential effects of river regulation, and whether or not it prevents spawning and/or limits successful recruitment (Humphries & Lake 2000). This study will compare the drifting larval fish assemblages between the free flowing Gasconade River and the regulated Osage River – two lower Missouri River tributaries in central Missouri, USA, to investigate how hydroelectric dams impact fish reproduction. The Gasconade River is a sixth-order stream at the confluence with the lower Missouri River, has a mean annual discharge of 86.65 cubic meters per second (cms), and is free of dams or impoundments through its entire 436 river kilometers (rkm) length (Table 1). In contrast, the Osage River is an eighth-order stream at the confluence with the lower Missouri River, has a mean annual discharge of 348 cms, and is regulated by hypolimnetic releases from Bagnell Dam, Lake of the Ozark’s hydroelectric plant at rkm 130 (Table 1). The lower Osage River is further altered by an obsolete low head dam known as Lock and Dam #1 located at rkm 19. Although, the Osage River basin is approximately three times larger than the Gasconade River basin they warrant comparison since they are in close proximity (i.e., the Osage confluence is 40 rkm upstream of the Gasconade confluence), have similar percent land use/cover, and have historically similar fish species (Table 1; Figure 1).

This study aims to compare larval fish family richness, presence, contribution, and relative abundance related to date, temperature, and discharge. This study is important because reproductive recruitment of some native fishes (e.g., blue sucker, paddlefish, and pallid sturgeon) are on the decline in this region as a result of impoundments and dams. We hope this study will give insight as to what criteria (i.e., discharge and temperature) trigger fish to spawn and reproduce, and aid managers within the region in deciding what modifications to river regulation are required to mimic a more natural system to conserve native fishes. We hypothesize (1) that the regulated Osage River will have less family diversity, and (2) that the Osage River will have a shorter window of optimal conditions (i.e., temperature and discharge) to trigger majority of fish to spawn at maximum densities.

<table>
<thead>
<tr>
<th>Stream order</th>
<th>Osage</th>
<th>Gasconade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoirs</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Basin area (km²)</td>
<td>27,781</td>
<td>9,256</td>
</tr>
<tr>
<td>Mean Annual Discharge (m³/s)</td>
<td>348</td>
<td>86.65</td>
</tr>
<tr>
<td>Grassland/ Pasture</td>
<td>44%</td>
<td>38%</td>
</tr>
<tr>
<td>Forest</td>
<td>30%</td>
<td>51%</td>
</tr>
<tr>
<td>Cropland</td>
<td>14%</td>
<td>3%</td>
</tr>
<tr>
<td>Impervious Urban</td>
<td>14%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Table 1. Comparison of Osage and Gasconade rivers and basin. Data are from the Missouri Resource Assessment Partnership (1999) and state of Missouri Landcover.

Figure 1. Map of the Osage and Gasconade rivers at their confluence with the Missouri River. The red dots indicate where larval sampling took place from March 20 to July 3, 2013. Lake of the Ozarks, Bagnell Dam is not depicted but is located at rkm 130 upstream of the Osage and Missouri River confluence.

Figure 2. Picture of the 0.5 m diameter, 500 micron mesh ichthyoplankton net with a suspended flow meter used for larval fish sampling and to calculate volume of water sampled.

METHODS
Larval sampling occurred during daylight hours for each river once a week from March 20 to July 3, 2013 at one transect 14.5 rkm from the Missouri River confluence in the Osage River and 3.2 rkm from the Missouri River confluence in the Gasconade River (Figure 1). Larval fish were collected using a 0.5 m diameter, 500 micron mesh ichthyoplankton net with a suspended flow meter at three locations along the transects: left descending bank, middle of the river, and right descending bank (Figure 2). Flow meter revolutions were recorded for each sample to determine water volume sampled (Figure 2). A sample was collected from the bottom third and the top third of the water column for roughly 10 minutes for a total of 6 samples per transect. Samples collected in the field were preserved in 10% formalin, dyed with eosin Y, and sorted in the laboratory at a later date.

Identifying larval fish to family level was accomplished with Auer (1982). Family abundance, or catch per unit of effort (CPUE) is the number of fish captured per 100 cubic meters (m³) of water sampled. CPUE was calculated for each of the 6 samples and then averaged for the day to represent the number of fish/100m³ of a particular family drifting down the river on the day of sampling. Maximum CPUE is the highest CPUE for a particular family during the sampling period. Larval fish were quantified by family presence, richness, and CPUE related to date, temperature, and discharge. Stream discharge data were obtained from the United States Geological Survey (USGS) online database, and stream temperature data were obtained from the USGS Columbia Environmental Research Center. CPUE was plotted with discharge and temperature to analyze triggers for peak CPUE and family richness through time. Tributary contribution of larval fish into the Missouri River was estimated using the CPUE calculated on the sampling date multiplied by the mean daily discharge within their corresponding week from April 12 to July 3, 2013 (i.e., when larval fish first appeared to the final day of sampling).
RESULTS
Throughout the sampling period (March 20 to July 3, 2013), the Osage River discharge ranged from 314 to 1201 cms with a mean of 830 cms. In contrast, the Gasconade River discharge ranged from 33 to 640 cms with a mean of 190 cms. Minimum discharge in the Osage River occurred on the same day, June 3, when the Gasconade River experienced its maximum discharge. Temperatures throughout the sampling period ranged from 6 to 25 °C in the Osage River, and 7 to 28 °C in the Gasconade River. Temporally, temperatures in the Osage River were consistently cooler, slower to rise, and were less variable compared to the Gasconade River (Figure 3).

The hypothesis that the Osage River would have less family diversity was unsupported. We collected a total of nine families between both rivers, eight from the Osage, and six in the Gasconade (Table 2). An overall total of 1,740 larval fish were collected in our drift nets, 987 in the Gasconade and 753 in the Osage River. Catostomids were 68% of the fish captured in the Gasconade River and 48% of the fish captured in the Osage River (Table 2; Figure 4). Clupeids were less than 1% of the fish captured in the Gasconade River and nearly half (48%) of the fish captured in the Osage River (Table 2; Figure 4). The presence of esocids were unique to the Gasconade River and the presence of atherinids, moronids, and sciaenids were unique to the Osage River. With the exception of scianids making up 6% of the Osage River total catch, all other unique and unidentified families made up less than or equal to 1% of the total catch within their respective rivers (Table 2; Figure 4).

Figure 3. Gasconade River (top) and Osage River (bottom) percid CPUE plotted with water temperature discharge from March 20 to July 3, 2013.

The hypothesis that some families in Osage River are limited by river regulation has some support. Percids in both rivers occurred at similar temperature ranges (14 to about 25° C), were present for the same number of days (about 66 days), and exhibited maximum CPUE on the same day (June 3) and at the same temperature (20°C; Figure 1). Percid CPUE appears to correlate with falls in the hydrograph approximately 15 days previously (Figure 5). However, percids in the Gasconade River were present 19 days and absent 15 days earlier than in the Osage River. In addition, maximum CPUE of percids and catostomids in the Gasconade River were 5 and 35 times less than in the Gasconade River, respectively (Table 2). In the Osage River, maximum CPUE of centrarchids, clupeids, and percids were all observed on the same day, June 3 (Table 2). Clupeids in the Osage River were more abundant than any other family with the highest maximum CPUE of 65,049 (Table 2). In the Osage River, clupeids were estimated to compose 97% of the drift and were likely a single species, gizzard shad *Dorosoma cepedianum* (Figure 4). In contrast, catostomids and percids composed of the majority of larval drift in the Gasconade River at 68% and 26%, respectively (Figure 4).

DISCUSSION
Both tributaries appear to be contributing substantial amounts of larval fish into the Lower Missouri River. However, river regulation may shorten the window of optimal conditions (i.e. temperature and discharge) to trigger spawning and allow larval development for the majority of species (Humpheries and Lake 2000). The Gasconade River does not have a mainstem dam and discharge is naturally governed by precipitation with some groundwater influences. In contrast, the Osage River has a large mainstem hydroelectric dam, Lake of the Ozark’s Bagnell Dam, located 130 rkm upstream of the Missouri River confluence that is known to regulate discharge. Even though both the Osage River and Gasconade River are in close proximity, their hydrographs...
did not appear to show a relationship. Moreover, the Osage River exhibited its lowest discharge on the same day that the Gasconade River experienced its greatest discharge, suggesting discharge is heavily regulated in the Osage River. In addition, as a result of hypolimnetic releasing through Bagnell Dam, water temperatures in the Osage River were buffered from the seasonal increase in air temperature with water temperatures cooler, slower to increase, and less variable week to week when compared to the free-flowing Gasconade River.

All of the top five most abundant families (i.e., percids, cyprinids, clupeids, centrarchids, and catostomids) were collected in the range of 13-25 °C, with maximum CPUE between 19 and 25°C except catostomids whose maximum CPUE was at ~14 °C in both rivers. However, the window of optimal conditions (i.e., temperature and discharge) for fish reproduction was likely limited in the regulated Osage River. Within both the Osage and Gasconade rivers, percids and catostomids include a wide range of riverine species that depend on specific discharge events for spawning and unique riffle habitat for rearing young (Aadland 1993). We found that between rivers, percids were present for a similar length of time and temperature range, but differed by when they appeared, suggesting percid spawning was offset in the Osage River. Catostomid maximum CPUE occurred at similar temperatures in both rivers but both percid and catostomid CPUE were likely limited as a result of regulation in the Osage River. We found that maximum CPUE of percids and catostomids in the Osage River were 5 and 35 times less than compared to the free-flowing Gasconade River, respectively.

Maximum CPUE of families produced in the Gasconade River did not occur on the same day. In contrast, the three most abundant families that occurred in the Osage River (i.e., centrarchids, clupeids, and percids) exhibited maximum CPUE on the same day, June 3, when the Osage River experienced its lowest discharge. The result of withholding hypolimnetic discharge from the Osage River may have increased temperatures to permit those families larval fish to develop and enter the drift, thereby achieving maximum abundances.

Larval fish typically feed exclusively on zooplankton (Post and Kitchell 1997). With maximum densities of larval fish occurring simultaneously, the potential for inter and intra specific competitive interactions between larval fish and other adult zooplanktivore fishes can be high, subsequently impacting larval fish growth and survival (Bystrom and Garcia-Berthou 1999). Therefore, regulation in the Osage River indirectly has the potential to increase competitive interactions and ultimately impact fish community dynamics.

The overwhelming contribution of clupeids from the Osage River is likely the result of a single species, gizzard shad, reproducing in the channel and upstream reservoir. Contribution of clupeids in the Osage River were estimated to be 64 times the second most contributed family, percids, from the Osage River to the Missouri River. Gizzard shad are prolific spawners, existing in high abundances within reservoirs or low gradient rivers with large pools (Pfleiger 1975). Our findings suggest river regulation in the Osage River increases...
the contribution of some lentic species (i.e., gizzard shad) and conversely limits the reproduction of some lotic fishes that depend on natural discharge temperature regimes (i.e., catostomids and percids). Similar findings were reported by Mu et al. (2014), where the proportion of lentic fishes increased by 13% and the proportion of lotic fishes decreased by 17% after the construction of a large hydroelectric dam.

Channelization and damming in the lower Osage River appears to have an impact on the larval fish assemblage but the extent of the effect may differ by taxa. Although they occur in the Missouri River, no larval paddlefish (*Polyodon spathula*), sturgeon (*Acipenseridae*), or blue sucker (*Cycleptus elongates*) were collected. Ongoing research in the lower Osage River should include additional monitoring of larval fish with a wider range of sampling techniques and gears (e.g., nighttime drift net, and light trap sampling), experimental releases, and quantifying riffle habitats to further delineate how river regulation impacts the early life histories of fish and the larval fish contribution of tributaries to the Lower Missouri River.

**LITERATURE CITED**


The Role of Parents’ Marital Status in the Association Between Young Women’s Relationships with Their Fathers and Romantic Partners

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Department of Psychological Sciences

Abstract
The quality of the father-daughter relationship could affect young women’s romantic relationships because better father-daughter relationships have been associated with better quality romantic relationships. We hypothesized that the association between negative relationships with fathers and negative relationships with romantic partners would be stronger for women who experienced separation from their fathers than for those who did not; we also hypothesized that the association between positive relationships with fathers and positive relationships with romantic partners would be stronger for women from intact families.

The sample consisted of 62 women who were enrolled in their first year of college. They were given the Network of Relationships Inventory, a widely used questionnaire that assessed the women’s positive and negative relationship qualities with their fathers and romantic partners.

There was a significant main effect of parents’ marital status. Women from non-two parent homes reported greater romantic negativity than those with married parents. There was also a significant main effect of positivity with fathers, such that greater positivity in the father-daughter relationship predicted less negativity in romantic relationships, but this effect was qualified by a marginally significant interaction with marital status. The association between father positivity and romantic negativity was only significant for women from non-intact families.

INTRODUCTION
Today, nearly half of all marriages end in divorce (Amato & Irving, 2006). Divorce creates stress in the lives of individuals, and this stress transcends such boundaries as race, culture, or nationality (Amato, 2000). Divorce not only has the potential to create stress for the partners who were once married, it can also have negative effects on the offspring of the partners. More than 40% of children born to married parents will experience the negative effects of parental divorce (Emery, Otto, & O’Donohue, 2005). Extant research has found that a decline in father-adolescent closeness is typically characteristic of parental divorce (Guttman & Rosenberg, 2003; Scott, Booth, King, & Johnson, 2007). Because divorce usually results in the father becoming the nonresidential parent, the father-adolescent relationship must be redefined and renegotiated (Guttman & Rosenberg, 2003). More specifically, regarding the father-daughter relationship, substantial research has found that the quality of the father-daughter relationship tends to be associated with the quality of daughters’ romantic relationships (Scharf & Mayseless, 2008; Dalton, Frick-Horbury, & Kitzmann.
relationships. Life satisfaction and also for their perceptions of their romantic partners could have negative consequences for the women's perception that fathers are not doing all that they can do in regards to parenting could have negative consequences for the women created emotional barriers, which further eroded the father-daughter relationship. Daughters may feel that their fathers could be doing something more within the father-daughter relationship. 

Post-Divorce Father-Daughter Relationship

Mothers' closeness with their children is practically unchanged following divorce (Scott et al., 2007), presumably because mothers tend to be the custodial parents after the dissolution of a marriage. Fathers typically do not have the experience of living with their children after divorce, and because of this change in residential status, father-child closeness tends to decline (Scott et al., 2007). Compared to sons, however, daughters may be more vulnerable to experiencing a decline in father-offspring closeness (Scott et al., 2007). As was found in one qualitative study, early adolescent ethnic minority girls from low-income families described their relationships with their mothers in terms of shared intimacies, but described their relationships with their fathers in terms of shared activities, such as going to the movies or playing sports with their fathers (Way & Gillman, 2000). There are fewer opportunities for non-residential fathers to consistently share these types of activities with daughters. Because women with nonresidential fathers do not have as many opportunities to interact with their fathers, they may report feeling closer to their mothers because it is likely that they share intimacies with their mothers more than they share activities with their fathers.

Young women with divorced parents have also been found to rate their fathers more negatively than their mothers (Hayashi & Strickland, 1998), which is likely explained by children of divorce feeling more disconnected from their fathers than do children from intact families; they also tend to feel more distant as they age (Guttman & Rosenberg, 2003; East, Jackson, & O'Brien, 2006). There are also additional possible explanations for why fathers are rated more negatively than mothers. For one, adolescents tend to separate from their parents as they get older, and divorce could exacerbate this decline in closeness (Seifge-Krenke, Overbeek, & Vermulst, 2010). Furthermore, mothers may openly complain about and criticize their children’s fathers, which could be worse for daughters because they are more likely than sons to agree with their mothers’ negative disclosure (Kenyon & Koerner, 2008). Finally, East et al. (2006) conducted a qualitative study and found that the women in the sample desired loving, intimate relationships with their fathers, but since they perceived their fathers as distant, disinterested, and unworthy of respect, the women created emotional barriers, which further eroded the father-daughter relationship. Daughters may feel that their fathers could be doing something more within the father-daughter relationship (East et al., 2006; Way & Gillman, 2000), and the perception that fathers are not doing all that they can do in regards to parenting could have negative consequences for the women's life satisfaction and also for their perceptions of their romantic relationships.

Effects of Parental Conflict on Daughters’ Romantic Relationships

Parental conflict also plays a role in offspring romantic relationships. Adolescents with divorced parents reported observing more parental conflict than did those from intact families (Hayashi & Strickland, 1998), and it has been found that children who witness a great deal of parental conflict are likely to have low efficacy beliefs in regards to their own relationship conflict (Cui, Fincham, & Pasley, 2008). Low efficacy beliefs are demonstrated through little to no effort in engaging in conflict resolution discussions, or if a person does engage in these discussions, they exhibit poor conflict resolution behaviors (Cui et al., 2008). These low efficacy beliefs were associated with poorer conflict resolution behaviors and decreased relationship satisfaction between the couple (Cui et al., 2008). Additionally, late adolescents with divorced parents reported less positive and more negative conflict resolution behaviors in their relationship with their fathers as compared to those from intact families (Reese-Weber & Kahn, 2005), which could be due to the aforementioned lower efficacy beliefs regarding conflict resolution (Cui et al., 2008).

Conflict tactics may be learned through experiences with family member and peers (Crockett & Randall, 2006; Cui & Fincham, 2010). Parental conflict could affect young adults’ romantic relationships through reshaping their conflict behaviors with their romantic partner (Cui & Fincham, 2010). Furthermore, high levels of parental conflict had a negative impact on the romantic development of the parents’ children. When parental marital relationships consisted of high discord, it was likely that the

Implications of Fathers’ Parenting

Perceptions of nurturant fathering during adolescence for emerging adult women have been found to be strongly related to life satisfaction (Allgood, Beckert, & Peterson, 2012). In addition to women’s overall life satisfaction, fathers’ parenting was also related to the quality of young adults’ relationships with a romantic partner, and was associated with young adults’ belief in being capable of forming secure and close romantic relationships (Dalton et al., 2006), but, as mentioned, this study did not take into account parents’ marital status, which could possibly act as a moderator between the quality of the relationships that young adult women have with their fathers and with their romantic partners. Better father-daughter relationships also have been found to be associated with longer-lasting romantic relationships once they are formed, both concurrently and longitudinally. When fathers exhibited relatedness, which is associated with better quality relationships and encompasses characteristics such as warmth, open communication, and acceptance, there was a positive association with the length of their daughters’ romantic relationships (Scharf & Mayselless, 2008). Nonresidential fathers may be less likely than residential fathers to demonstrate warmth, open communication, and acceptance because of the decline in father-daughter closeness (Scott et al., 2007). One study found that less than one-third of nonresident fathers communicate with their offspring at least once a week (Manning & Smock, 1999), so young women from non-intact homes may be more likely to be dissatisfied in their romantic relationships because they typically do not have close relationships with their fathers. Although paternal parenting is related to women’s romantic relationships, there are other interacting factors that contribute to the quality of young women’s romantic relationships.
romantic relationships of their children would also contain high levels of discord (Seiffge-Krenke & Shulman, 2012). These findings lend credibility to social learning theory, which posits that people learn attitudes and behaviors by observing their environment (Bandura, 1977). Seiffge-Krenke & Shulman (2012) found that adolescent couples who successfully resolved their relationship conflicts stayed together for a longer period of time. It could be argued that those who observed their parents demonstrating positive, successful conflict resolution behaviors held higher relationship efficacy beliefs, which made them more adept at resolving conflict than those who witnessed frequent, poorly resolved parental conflict.

Attitudes about Divorce
Numerous studies have found that children of divorce are more likely to be divorced than children from intact families, which is known as the “intergenerational transmission of divorce” (Hayashi & Strickland, 1998). By witnessing parental behavior leading up to divorce, children could develop a negative attitude about relationship commitment (Shulman, Zlotnik, Shachar-Shapira, Connolly, & Bohr, 2012). This negative attitude about relationship commitment may manifest itself through a habit of dissolving romantic relationships as soon as conflict appears, and being less inclined to try to resolve disagreements (Shulman et al., 2012; Cui & Fincham, 2010). Adolescents from divorced families showed weaker skills in resolving conflicts that are inevitable in romantic relationships (Shulman et al., 2012). In fact, parental divorce predicted shorter romantic relationships (Shulman et al., 2012), and girls from divorced families were less likely to be involved in stable, long-lasting relationships (Shulman et al., 2012). This could be due to the amount of parental conflict that children witness that leads up to the divorce, rather than to the divorce itself (Cui et al., 2008). If children of divorce do not know how to successfully resolve conflict, then they may be less satisfied and less committed in their romantic relationships.

The Role of Fathers in Regards to Daughters’ Romantic Relationships
The family is considered to be an important training ground for romantic relationships (Crockett & Randall, 2006). Mixed-sex parent-child interactions are usually based on traditional gender roles, especially the father-daughter relationship (Laursen & Bukowski, 1997). The skills involved in interacting with romantic partners appear to be learned by early interactions with the opposite-gender parent (Seiffge-Krenke & Shulman, 2012). Girls learn how to form and maintain romantic relationships within the parent-child dyad (Scharf & Mayselss, 2008). Fathers provide a safe space wherein their daughters can learn to interact with the opposite sex (Scharf & Mayselss, 2008). More specifically, fathers teach their daughters, albeit indirectly, how to behave with another man in the context of a romantic relationship (Scharf & Mayselss, 2008). Girls who live apart from their fathers will presumably lack this type of father-daughter interaction that teaches them how to interact with the opposite sex. Because of this, they may be at a disadvantage in their romantic relationships compared to girls who live with their fathers. If girls do not know how to interact with their romantic partners, then that could potentially lead to less relationship satisfaction.

The Present Study
The present study investigates how emerging adult women who had residential fathers and those who had nonresidential fathers compare in the strength of the association between the quality of the relationship that they have with their fathers and romantic partners. Previous studies have found that daughters tended to describe their relationships with their fathers in terms of shared activities (Way & Gillman, 2000), and also that fathers’ parenting was related to the quality of young adults’ relationships with a romantic partner (Dalton et al., 2006). Fathers who are in the home with their daughters have significantly more opportunities to share activities with and actively parent their daughters than fathers who are residually separated from their daughters. Based on these studies, we hypothesized that the strength of the association between the quality of the relationship that emerging adult women have with their fathers and romantic partners will be moderated by their parents’ marital status.

Better quality father-daughter relationships have been found to be related to longer lasting romantic relationships once they are formed concurrently and longitudinally (Scharf & Mayselss, 2008), but many women who live apart from their fathers perceive their fathers to be distant and disinterested, which could result in poorer father-daughter relationships (East et al., 2006; Radina, 2003). For this reason, we hypothesized that the association between father negativity and romantic negativity would be stronger for young women who experienced residential separation from their fathers than for those who did not; conversely, we also hypothesized that the association between father positivity and romantic positivity would be stronger for young women from intact families.

METHOD
Participants
First-year college students were recruited from introductory psychology courses at a large Midwestern university. The data was originally intended for a study on how family relationships change during the transition to college, but for the purposes of the present study, data was only included for female participants who reported being in a romantic relationship. The final sample consisted of 62 emerging adult women, averaging 18.32 years of age (SD = 0.90). Participants either had married parents (n = 38) or divorced or single, never married parents (n = 24). Most participants were White (88.7%); Black/African American, 8.1%; Hispanic, 1.6%; Asian/Pacific Islander, 1.6%). The median annual parental income was $70,000-$84,000. Most participants reported that their parents were college educated; 40.3% of parents had a four-year college degree, while 31.4% of parents had a graduate degree.

Measures
Positive and Negative Relationship Quality.
Participants were given the Network of Relationships Inventory (NRI: Furman & Buhrmester, 1985), which is a widely used questionnaire that assessed the women’s perceptions of positivity, which consisted of 24 items that included intimacy, affection, and support. It also assessed the women’s perceptions of negativity, which was comprised of 9 items that included conflict and criticism. Participants separately rated the extent to which each item on the NRI described their relationship with their father.
and romantic partner. Cronbach alphas indicated high internal consistency (father positivity = 0.94, father negativity = 0.92, romantic partner positivity = 0.97, romantic partner negativity = 0.93). Mean scores for positivity and negativity for each relationship were used in

**Procedures**

Students enrolled in introductory psychology classes who met the eligibility criteria for the broader study (first year college students between 17 and 25 years of age and either a first- or second-born child in their family) were emailed an invitation to participate in the study once their name was chosen from the broader list of those eligible using a random number generator. Those who responded with interest were sent a link to an online questionnaire, where they consented to participate in the study and answered demographic questions and questions about an array of characteristics of their close relationships. Students received course credit for participating in the study.

**RESULTS**

**Descriptive Statistics**

The means, standard deviations, and intercorrelations among the study variables are shown in Table 1. Emerging adult women reported greater father positivity when they were from intact families than when they were from non-intact families. Conversely, women reported greater romantic negativity when they were from non-intact families than when they were from intact families. There were no significant associations between father negativity or romantic relationship positivity with parental marital status. For the entire sample of women, there was a significant negative correlation between father positivity and father negativity, such that more father positivity was significantly associated with less father negativity. Additionally, there was a significant negative association between father positivity and romantic negativity, such that greater father positivity was significantly associated with less romantic negativity.

**Table 1. Means (Standard Deviations) and Intercorrelations among Major Study Variables**

<table>
<thead>
<tr>
<th>Mean (SD)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Intact (1=intact, 2=non-intact)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. Father Positivity</td>
<td>3.45 (.80)</td>
<td>-26**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Father Negativity</td>
<td>1.88 (.77)</td>
<td>.13</td>
<td>-.49**</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4. Romantic Positivity</td>
<td>4.14 (.70)</td>
<td>-.05</td>
<td>-.05</td>
<td>-.18</td>
<td>-</td>
</tr>
<tr>
<td>5. Romantic Negativity</td>
<td>1.78 (.70)</td>
<td>.25*</td>
<td>-.30*</td>
<td>.2</td>
<td>-.08</td>
</tr>
</tbody>
</table>

**Note:** +p<.10 *p<.05 **p<.01

**Table 2. Associations between Perceptions of Relationships with Fathers and Perceptions of Relationships with Romantic Partners**

<table>
<thead>
<tr>
<th>Father Pos.</th>
<th>Father Neg.</th>
<th>Father Post</th>
<th>Father Neg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔF</td>
<td>ΔR2</td>
<td>β</td>
<td>ΔF</td>
</tr>
<tr>
<td>Intact</td>
<td>.12</td>
<td>.00</td>
<td>4.13*</td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>.23</td>
<td>.00</td>
<td>2.13</td>
</tr>
<tr>
<td>Step 3</td>
<td>.59</td>
<td>.55</td>
<td>-10</td>
</tr>
<tr>
<td>Relationship</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRxIntact</td>
<td>-.92</td>
<td>.52</td>
<td>.10</td>
</tr>
<tr>
<td>Step 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** +p<.10 *p<.05 **p<.01 All βs represent the final step of the analysis.

Only the association between emerging adult women’s reports of positivity in their relationships with their father and negativity in their romantic relationships produced significant results. First, and similar to the correlations, a significant main effect of parents’ marital status was evident. Emerging adult women who were from non-two-parent homes reported greater romantic negativity than those who had married parents. Additionally, prior to including the interaction in the model, there was a significant main effect of positivity with fathers, such that greater positivity in the father-daughter relationship was associated with less negativity in romantic relationships. A marginally significant interaction with marital status was obtained and thus probed further for interpretation by graphing the interaction and conducting simple slopes analyses. The simple slopes indicated that the association between father positivity and romantic negativity was only significant for women from non-intact families (intact: t = 1.86, p = .07; non-intact: t = -1.95, p = .05).

**Figure 1. Interaction of Family Status and Father Positivity and Romance Partner Negativity**

![Figure 1. Interaction of Family Status and Father Positivity and Romance Partner Negativity](image)
DISCUSSION

The present study examined how emerging adult women with married and non-married parents compared in the strength of the association between the quality of the relationship that they have with their fathers and with their romantic partners.

The first hypothesis, that the quality of the relationship that emerging adult women have with their fathers would be positively associated with the quality of their relationships with their romantic partners, was partially supported. Greater father positivity was significantly associated with less romantic negativity, but this association was only true for women from non-intact families. This was a surprising finding because women from intact families reported greater father positivity, but this was not associated with less romantic negativity for them, even though previous research has found that higher quality father-daughter relationships were associated with longer lasting romantic relationships (Scharf & Mayseless, 2008). This may be because stronger relationships with fathers may make it more difficult for romantic partners to live up to the standards set by the women’s fathers.

For women from non-intact families, father positivity was beneficial to their romantic relationships because it was significantly associated with less romantic negativity. Perhaps this finding emerged because fathers’ parenting has been found to be associated with young adults’ beliefs in being able to form close romantic relationships (Dalton et al., 2006), and women who have positive relationships with their fathers might have positive internal working models of close relationships, and these positive internal working models may work against negativity in their romantic relationships. It is likely that women from non-intact families do not interact with their fathers as much as women from intact families, so high quality father-daughter relationships for women from non-intact homes may keep them from seeing relationships negatively and/or keep them from engaging in negative relationships.

The second hypothesis, that the association between negative relationships with fathers and negative relationships with romantic partners would be stronger for women from non-intact families, was not supported. Perhaps the association between negative relationships with fathers and negative relationships with romantic partners was not stronger for women from non-intact families because they may have had support from their mothers regarding their romantic relationships, and maternal support has been found to significantly explain daughters’ romantic competence, which alleviated the effects of divorce (Shulman et al., 2012). Shulman et al. (2012) found that when mothers supported their daughters’ romantic relationships and reported trusting their daughters’ dating behaviors, their daughters were more likely to be involved in longer lasting romantic relationships, to hold more positive and mature beliefs about romantic relationships, and to show more adaptive skills in handling their romantic relationships. Because the present study did not measure daughters’ perceived support from their mothers, it is hard to gauge whether having maternal support contributed to the finding that the association between negative relationships with fathers and negative relationships with romantic partners was not stronger for women from non-intact families.

Finally, contrary to our hypothesis, the association between positive relationships with fathers and positive relationships with romantic partners was not stronger for women from intact families. Perhaps father positivity is not associated with positivity in romantic relationships because it may be easier to identify negativity (such as conflict, criticism, or antagonism) because it is often associated with specific events (such as arguments), whereas it may be more difficult to notice components of positivity (such as warmth or support) in these close relationships because positivity is typically thought of in terms of the overall context or tone of the relationship.

Although the present study increased our understanding of the impact of the quality of father-daughter relationships on daughters’ romantic relationships, it does not come without its limitations. One of the primary limitations of the present study is that the sample of women was extremely homogeneous. Approximately 89% of the participants were White, middle-class women. Thus, the present study lacks generalizability. Future research should seek to replicate the findings from the present study, but should also use more ethnically diverse women and women with different socioeconomic statuses. A second limitation is that we do not know when parents divorced or how long (or if) women and their fathers had been residentially separated, nor do we know how long the women had been in their current romantic relationships. The timing of parental divorce and the length of women’s current romantic relationships are both variables that could have affected the quality of the women’s paternal and romantic relationships. We also do not know how often daughters see their fathers, which would presumably affect how much positivity they report in their relationships with their fathers (Radina, 2003). Future research should examine if the timing of parental divorce, the length of romantic relationships, and the frequency that daughters see their fathers affects the association between the quality of the relationship that women have with their father and romantic partners. Finally, although an experimental design would not have been possible because it is impossible to manipulate parents’ marital status, the correlational nature of the present study does not allow for inferences about causality to be made. Future research should examine these effects longitudinally, as that would allow conclusions about the direction of the effects to be made.

Despite the limitations of the present study, the associations found help elucidate the relationships between parental divorce and the quality of the father-daughter relationship, and how the quality of the father-daughter relationship affects the quality of romantic relationships. Specifically, because the association between father positivity and romantic negativity was only significant for women from non-intact families, those women seem to be protected in their in their relationships by continuing positive relationships with their fathers. Therefore, to ensure that emerging adult women have high quality romantic relationships, it is especially important that fathers continue to be active, supportive, and present figures in the lives of their daughters, even into adulthood.
REFERENCES


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SHawna Rowe is a biochemistry major from Marshfield, Missouri. She is the recipient of the Excellence Scholarship and the Wurdack Scholarship. She is active with the MU Sustainability office, the Office of Undergraduate Research, Caring for Columbia and the Armory Community Center.

This summer, Shawna spent her time in an undergraduate research program at Michigan State University before completing her senior year back here at MU.

INTRODUCTION
Plant survival depends on a plant’s ability to efficiently defend itself against potential microbial pathogens. Resistance occurs through a multi-layered immune system. The first layer involves recognition of an invading pathogen by perception of a PAMP (Pathogen Associated Molecular Pattern). PAMPs are molecules only found in microbes that are essential for survival, such as bacterial elongation factor Tu (EF-Tu) which is required for protein synthesis. Recognition of EF-Tu by the EFR receptor triggers a number of molecular events that result in changes aimed at preventing further microbial growth. These events include transcriptional changes, MAPK (Mitogen-Activated Protein Kinase) activation, and Ca2+ signaling. While a lot of information is known about these rapid responses, how these molecular events connect recognition with biological responses is not fully understood. One obstacle that exists in understanding these events is the issue of gene redundancy, which is when a specific biochemical function is encoded by more than one gene. Since many genes are often associated with overlapping functions, we designed artificial microRNA (amiRNAs) to target and knock down transcript levels from entire families of related genes (Hauser et al, 2013). By screening these amiRNA lines, one of them was identified to have an altered growth phenotype in response to EF-Tu. Additionally, qRT-PCR analysis indicated an altered phenotype of early PAMP responses. I am currently investigating additional molecular markers to determine the extent of altered responses to EF-Tu. By using qRT-PCR we were able to determine that nine genes had effectively been targeted by the amiRNA, and their transcript levels were reduced. In addition to determining all of the altered phenotypes, the goal is to identify which of the targeted nine genes are responsible for the altered phenotypes. This research has potentially revealed novel components in defense responses of plants to microbial pathogens and aims to provide future directions for additional investigation of these genes.

LITERATURE REVIEW
I. PATHOGEN RECOGNITION
Activation of a plant’s immune system is dependent on the plant being able to recognize that a potential pathogen is present. This strategy of non-self-recognition is accomplished by the detection of proteins or small molecules that originate from the pathogen but are not present in the host plant. Plant recognition of these molecules, also called elicitors, triggers a number of different defense responses that can prevent the growth of the pathogen, thereby preventing the progression of the disease symptoms.
**Pathogen-Associated Molecular Patterns**

Non-self-recognition of pathogens by plants requires the detection of pathogen-associated molecular patterns or PAMPs. PAMPs are small molecules or proteins that are not specific to the particular pathogen but are highly conserved among most pathogens (Goméz-Goméz and Bolier, 2002). Another characteristic of PAMPs is that they are essential to the life of the pathogen. Therefore, the microbe is not able to eliminate or mutate the PAMP in an attempt to avoid detection. This strategy of general recognition of potential pathogens efficiently allows the plant to protect itself from a wider number of potential microbial pathogens.

**PAMP Perception**

Plants recognize the presence of PAMPs through pattern recognition receptors, or PRRs, on the plant cell surface. PRRs have a high affinity and a high specificity for individual PAMPs to ensure that the plant’s immune system is triggered only at the appropriate time to avoid potentially detrimental effects from aberrant activation of defense responses. PRRs are proteins that traverse the plasma membrane enabling extracellular perception of pathogens to trigger immune responses within the cell. For instance, the perception of EF-Tu occurs by the PRR known as the EF-Tu Receptor (EFR) (Zipfel et al, 2006). EFR is a leucine-rich repeat (LRR) receptor-like kinase, or LRR-RLK. In the instance of EF-Tu, EFR recognizes a highly conserved epitope that is estimated to be around 20 amino acids in length (Kunze et al, 2004). While this particular PRR and response has only been found in Brassicaceae species, similar types of recognition occurs for additional PRRs specific for other elicitors. An example is flagellin, a commonly studied PAMP in plant immunity. Flagellin is a globular protein that provides structure to bacterial flagellum and is necessary for bacterial mobility. Flagellin provide locomotion to most bacteria and are not present in plants thus placing them in the category of PAMPs (Kojima et al, 1999). It is recognized by a LRR-RLK known as FLS2 that is similar in structure and activity to EFR (Nicaise et al, 2009).

Upon perceiving a potential pathogen, plants undergo a series of biochemical responses that ultimately result in resistance against pathogen growth, a process called PAMP-triggered immunity (PTI). While some of these responses involved in PTI are well understood, the specific responses connecting perception with immunity is not known. To improve resistance against pathogens in crop plants, it is necessary to identify these important pathways and processes that are required for PTI.

**II. DEFENSE RESPONSES**

Successful signal propagation results in a number of defense-related responses including transcriptional changes. Ultimately, some or all of these effects result in the manifestation of resistance by inhibiting growth of the bacteria.

**Transcriptional Changes**

A major target of PAMP signaling is the transcriptional activation or repression of many genes. Transcriptional responses likely contribute to a number of physiological responses within the plant including the strengthening of the cell wall, ability to resist pH changes that can occur to inhibit bacterial growth, and/or reallocation of energy through metabolic reprogramming. Members of several transcription factor (TF) families have been observed to be targeted by early signaling events and play a significant role in coordinating these changes in transcriptional activity.

One of the most-studied TF families in plant defense responses is the WRKY family. Arabidopsis thaliana has been shown to contain 72 WRKY genes. This large family of transcription factors is so named due to the highly conserved amino acid sequence WRKY that is present in all members. A number of specific WRKY proteins show enhanced expression after defense induction by pathogens. For instance, many WRKY factors have been linked to the MAPK signaling cascades in Arabidopsis (Ishihama and Yoshioka, 2012). While evidence indicates that these genes have a role in defense responses, it is unclear which specific immune responses are regulated by these transcription factors (Eulgem and Somssich, 2007).

**Growth Inhibition is a Negative Consequence of Defense Induction**

A negative outcome resulting from activation of defense responses is that plants with enhanced resistance tend to experience severe growth inhibition. Thus, although it is possible to induce enhanced resistance against pathogen invasion by pre-activating defense responses, the result is a plant with greatly decreased stature and agricultural yield (Alcázar et al, 2011). While it is important for a plant to be able to achieve resistance against pathogens, severe growth inhibition is counterproductive to the theoretical agricultural and economic benefits gained from conferring resistance to pathogens. Therefore, there would be tremendous value in identifying genes that may allow enhanced defense responses without the extreme fitness costs that typically occur upon inducing immunity.

**III. GENE REDUNDANCY**

Within genomes, large gene families with highly similar sequences are a common occurrence in most organisms. Redundancy of related genes/proteins usually means that the gene products partially or fully overlap in function. Therefore, standard genetic screens may be ineffective in identifying genes important for certain responses when a second gene can mask the loss of another gene.

**IV. AIMS FOR THE PROJECT**

A plant’s ability to effectively and efficiently defend itself against microbial pathogens is critical to its overall growth, health and capacity to reproduce. However, pre-inducing resistance generally results in decreased yield, which is detrimental to the desired goal of improving food production. Therefore, a better understanding of the specific mechanisms of the defense pathways in plants will be crucial to understanding ways to genetically engineer and/or construct plants with a greater capacity to fend of pathogens and other potential biological threats without the additional fitness penalties.

We hypothesize that the ability to navigate around the barrier created by natural gene redundancy will provide the means to identify genes that play critical roles in the
processes of microbial defense (Hauser et al, 2013). This project aims to identify particular families of genes that are closely related in function that may play important roles in plant immune responses. Using artificial microRNAs (amiRNAs) designed to target short, conserved sequences, the specific gene families have been targeted to reduce transcript accumulation, thus knocking down the levels of the protein family. This approach allows us to screen for phenotypes that were otherwise undetectable due to functional redundancy.

Further understanding of why defense responses result in severe growth inhibition may allow for the capacity to constitutively activate defense responses without extreme fitness costs to the plant. Having this capacity would prove to be an invaluable tool for crop production and would have significant agricultural and economic benefits. Crops with improved immunity and yield will benefit food production, textile industries, and the energy market.

METHODS AND MATERIALS
Plant materials and growth conditions
Arabidopsis seeds were sterilized with 0.5% sodium hypochlorite for 20 min, rinsed with water, and plated aseptically on 0.6% agar containing 2.1 g L−1 Murashige and Skoog (MS) salts (Sigma, http://www.sigmaaldrich.com/), pH 5.7, and 1% sucrose. After stratification for 2 days at 4°C, seeds were germinated, and seedlings were maintained in a Percival Scientific growth chamber (http://www.percival-scientific.com/) at 21°C with a 9/15 h light/dark cycle. Seedlings were maintained in the same growth chamber under the same conditions during treatments.

Inhibition of seedling growth by elf26 treatment
Five-day-old seedlings were aseptically transferred from MS agar to wells of a 24-well microtiter plate (one seedling per well) containing 1 ml of liquid MS medium (2.1 g L−1 MS salts, pH 5.7, and 1% sucrose) with or without 1 μM elf26. After 10 days, seedlings were weighed and placed on an agar surface for photography and measurement of primary root length.

Transcript analysis using quantitative real-time PCR
For each treatment condition, four 11-day-old seedlings were transferred from MS agar plates to 1 ml of sterile H2O in a single well of a 24-well microtiter plate, and incubated overnight. For elicitor treatments, H2O from the overnight incubation was removed and replaced with sterile H2O containing 1 μM elf26. At 45 min post-elicitation, seedlings were frozen in liquid nitrogen. Total RNA isolated using TRI reagent (Sigma) was treated with DNase I (Fermentas, http://www.fermentas.com), and 1 μg of RNA was reverse-transcribed in 30 μl reactions containing 5 mM DTT, 1 μl RnaseOUT (Invitrogen, http://www.invitrogen.com) 2 μM oligo(dT), 1 mM each of dNTPs and 1 μl M-MLV reverse transcriptase (Promega, http://www.promega.com/) for 1 h at 42°C, followed by 5 min at 85°C. Reverse transcription reactions were diluted to 150 μl using autoclaved H2O. Real-time PCR reactions were performed essentially as described previously (Libault et al., 2007) using primers unique to the genes of interest. Briefly, 10 μl real-time PCR reactions containing 4 μl SYBR Green PCR master mix (Applied Biosystems, http://www.appliedbiosystems.com/), 1 μl cDNA and 0.2 μM of each primer were performed using an ABI7500 real-time thermal cycler (Applied Biosystems). Expression levels were calculated using the equation: expression level = (PCR efficiency)−ΔCt, where ΔCt = Ct (sample) – Ct (control), and Ct is the cycle threshold determined each for reaction using ABI PRISM 7000 SDS 1.0 software (Applied Biosystems). At4g28730 (Glutaredoxin-C5, chloroplastic) was used as the reference gene for normalizing Ct values. PCR efficiencies for each reaction were obtained using the software program LINREGPCR (Ramakers et al., 2003).

RESULTS
After various EF-Tu treatments, it was found that TPK 72-1-D and TPK 72-3-D had two altered responses. The growth inhibition experiment showed that the TPK lines were better able to grow when exposed to higher concentrations of EF-Tu (figure 1). The result was more significant at the lower concentration of the PAMP but the trend was present with both a 10 nM concentration and a 100 nM concentration.

![Figure 1. Growth of Inhibition of 5 day old seedlings using EF-Tu.](image)

A) Fresh weight of 5 day old Arabidopsis thaliana seedlings taken after 10 days of exposure to EF-Tu. T-test results provided p<0.01.

B) Fresh weight seedlings plotted as percentage. T-test results provided p<0.05.
DISCUSSION

After testing the immunity-related phenotypes described above, it appears that some combination of the nine targeted genes is involved in the cellular events connecting pathogen recognition and plant immune responses. The data suggests that the fitness trade-off is somehow altered in the TPK72 lines based on the changed responses to PAMPs that have been observed. In particular, the growth inhibition is interesting when the two graphs (figure 1) are compared. Graph A is plotted as relative expression and the wild-type plants grow larger at the 0 nM concentration. After treatment with the PAMP, the transgenic TPK lines are larger on average. In graph B, the results plotted as a percentage indicates better growth of the TPK lines under the PAMP stress condition. Using a Student’s T-test, the results were determined to be significant.

Furthermore, the altered expression of NHL10 (figure 2), a gene regulated by both MAP kinases and Ca2+ signaling, indicates that some combination of the TPK-target genes may be involved in the molecular events that occur within this(these) pathway(s). The assay determining the relative expression level of NHL10 will need to be repeated to gain more accurate information on the specific fold differences. Additionally, the expression of FRK1, a MAPK-specific gene, will need to be tested at a later time point of PAMP treatment. FRK1 is the FLG22-induced receptor-like kinase 1. Determining if this is altered in expression at the later time-point will provide additional information about the potential involvement of the reduced-function genes in MAPK pathways or other broad responses that are activated by PAMP recognition. By determining the status of these relative expression levels we will be able to better hypothesize at which point the TPK genes are functioning in immune responses.

While it seems that some combination of the genes that were determined to be knocked down (figure 3) is involved in altered immune responses, it is not clear which of the genes are involved. The next step in determining which genes are involved is continuing to perform additional assays to investigate other potentially altered immune phenotypes. Assays that measure Reactive oxygen species (ROS) production, bacterial growth and stomata development will be used to assess other known immune responses. Additionally, it is necessary to determine if the EF-Tu receptor has been altered in the TPK72 lines. Determining if the change is in the receptor will allow us to draw additional conclusions about where in the signaling networks the genes may be acting.

Finally, it is important to determine which of the nine genes are involved in the observed phenotypes. To do this, new amiRNA constructs will be designed to target specific subsets of the original nine genes. By performing the same assays and creating stable mutants of potential lines we will be able to determine which genes are...
contributing to the phenotypes of interest. The altered phenotypes of known immune responses have provided some information about additional genes that may be involved in immune responses of Arabidopsis thaliana. The genes targeted in the TPK72 lines are all contained in the Squamosa-promoter binding protein (SBP)-like family. This family’s distinguishing characteristic is the conservation of the SBP-domain and the targeted genes are the small to mid-sized genes within this gene family with nine of them successfully knocked down. These genes are typically induced as plants senesce (Birkenbihl et al, 2005). This fact makes it particularly interesting that these altered immune responses are occurring at the seedling stages of growth. This information may shed light on new functions of these genes that are apparent at earlier stages of the life cycle.

It is currently unknown what type of immune response has been altered within the TPK72 lines. The results from the bacterial pathogen growth assay would allow some light to be shed on this question. If we are able to determine that bacterial growth is restricted on the transgenic lines it could serve to indicate a change in the pathway regulating the hypersensitive response (HR) which serves as an innate antimicrobial mechanism.

While results of these additional assays are still pending, based on the preliminary findings it appears that a combination of the nine targeted genes is involved in the cellular communication that results in early immune responses. The targeted genes have previously been identified as critical during growth and development but this research indicates potentially new roles that some of the SPL genes may have in plants. This research has the potential to reveal novel players in plant immune responses and verifies the effectiveness of the amiRNA construct technique for targeting and knocking down gene families in order to determine the phenotypes of genes with shared functions.

REFERENCES
Azelnidipine attenuates alterations of cerebral endothelial functions induced by amyloid-β peptide

ABSTRACT

The oligomeric amyloid-beta (Aβ) either binds to cell surface receptors or inserting into the plasma membrane of the cell can trigger oxidative and inflammatory pathways, and result in alterations in cell membrane properties, Aβ induced NADPH oxidase-mediated reactive oxygen species (ROS) production stimulates the activation of downstream signaling pathways involving the activation of MAPK (mitogen-activated protein kinase) and ERK1/2 (extracellular-signal-regulated kinase 1/2), and phosphorylation of cPLA2 (calcium dependent phospholipase membrane protein). Azelnidipine is an L-type calcium channel blocker that causes vascular smooth muscle relaxation, and a drug commonly used to treat hypertension. Recent studies have suggested that the drug possesses an anti-inflammatory anti-oxidative effects in various types of cells. In the present study we examined if Azelnidipine was capable of attenuating the Aβ- induced cellular pathways of oxidative stress and inflammatory responses shown to alter endothelial functions using immortalized cerebral endothelial cells (bEND.3 cells). Specifically, we tested and found that Azelnidipine has potential uses in Alzheimer’s disease (AD) treatment by suppressing Aβ-induced oxidative and inflammatory pathways through the attenuation of ROS production. The results suggest that Azelnidipine might have potential application as a therapeutic strategy to treat Alzheimer’s and mediate oxidative stress induced pathology of neurodegenerative diseases such as AD.

INTRODUCTION

Alzheimer’s disease is a neurodegenerative disease characterized by the loss of cognitive functions that include memory loss and decreased thinking abilities. The most common form of dementia, and the sixth leading cause of death in the United States, Alzheimer’s is identified as a disease that primarily affects elderly individuals although early onset Alzheimer’s has been observed in individuals in their 40s and 50s. According to the Alzheimer’s Association, an estimated 5.2 million Americans of all ages currently live with AD in 2014, 5 million of those individuals the age of 65 or older. In particular there is a projected 40 percent increase for individuals 65 years and older by the year 2025 with no cure for the debilitating disease in sight. (Alzheimer’s Association)

Although the cause of this disease is not well understood, the presence of Aβ peptides in the brains of deceased AD individuals has led to studies of the role of this protein in AD. Everyone naturally produces some Aβ in their brains, but in patients who potentially have AD there is a buildup of Aβ that often results
in the formation of amyloid plaque deposits. Aβ produced in the brain begins as monomers that aggregate to form oligomers which further interact with each other to produce plaque. Initially these plaques were thought to be the cause of AD neuropathology. The soluble oligomeric form of Aβ has been found to be more cytotoxic to neurons and glial cells as compared to the plaques. Their presence creates a cascade of biochemical activities resulting in the destruction of synapses, and may activate immune system cells that trigger inflammation.

Oxidative stress plays a critical role in Alzheimer’s pathogenesis and results from an imbalance between the production of ROS and the antioxidant enzymes in the body ability to inhibit oxidative reactions and prevent accumulation of free radicals generated by excess ROS production. Accumulation of ROS causes damage to cellular components including DNA, calcium influx and results in the oxidation of lipids and amino acids that eventually lead to apoptosis or programmed cell death. In Alzheimer’s, patients suffer from loss of memory as a result of oxidative stress.

Previous studies have shown that Azelnidipine a hypertension drug and calcium channel blocker possesses antioxidative properties in endothelial cells and cardiomyocytes. Azelnidipine has been proven to promote a decrease inflammatory response and reduce intracellular levels of ROS. No studies have looked at the therapeutic effect that Azelnidipine might have in suppressing Aβ induced alteration to endothelial functions.

**LITERATURE REVIEW**

There was a trend established concerning the relationship between the gradual decline of neuron function in neurodegenerative disorders such as AD and Parkinson’s disease that involved Aβ attenuation of intracellular pathways of free radical generation which causes oxidative stress.1 Simonian and Croyle’s review of possible links between the intracellular pathways of ROS free radicals in neuronal degeneration in such diseases as Alzheimer’s in which the aggregation of amyloid beta to form Aβ plaques is a hallmark. Neurodegeneration has been contributed to Aβ toxicity. Early evidence suggested the possibility of oxidative stress involvement in Aβ toxicity by contributing to the aggregation of soluble Aβ into insoluble plaques.

The idea that oxidative stress is a result of Aβ induced free radicals has been established based on observations of previous literature. One effect of oxidative stress is lipid damage, known as lipid peroxidation, which produces a progressive loss of membrane fluidity, which reduces membrane potential, and increases permeability to ions such as calcium.1 The binding of reactive lipid peroxidation products results in the occurrence of Ca2+ dyshomeostasis. Mitochondrial oxidative metabolisms is one source of free radicals involved in oxidative stress leakage of electrons along electron transport chains which in turn causes the formation of free radicals those then result in ROS production. 1 Mitochondrion is instrumental in Alzheimer’s development through the promotion of oxidative stress driven excitotoxins.2 During state of oxidative stress the mitochondria can generate reactive oxygen species such as OH- when exposed to pathologic concentrations of calcium.1 The accumulation of ROS and subsequent changes in membrane characteristics leading to excess concentrations of calcium has also been evaluated in events proceeding at synapses of dendrites. Synaptic loss in cerebral cortex and hippocampus is a common symptom of progressive AD.2

Antioxidants are able to inhibit free radicals and suppress calcium influx there by protecting cells against Aβ-induced apoptosis.1,2 Aβ proteins share an ability to induce channel-like activity in membranes.7 Calcium and reactive oxygen species play important role and involvement in initiating mitochondrial membrane depolarization which result in activation of neuronal oxidative metabolism.12 Activation of glutamate-gated ion channels puts the mitochondria at risk of generating excessive amounts of ROS. The increased production of ROS damages mitochondrial proteins, DNA, and lipids, which may result in further generation of ROS and energy depletion. Research suggests there is possibly a defect in mitochondrial energy metabolism that could be possible cause of neuronal degeneration in neurodegenerative diseases.

Ekinici in 1999 built upon previous literature observations of Aβ-induced neurotoxicity, through Aβ treatment of cultured neurons and neuroblastoma. The study findings suggested that calcium influx particularly via the L voltage-sensitive calcium channel is responsible for Aβ induced attenuation of ROS. To study the intracellular pathways involving the factors that are responsible for development and progression of Alzheimer’s disease, Aβ treated cells were also treated with the antioxidant vitamin E as well as kinase inhibitor. In particular the antioxidant vitamin E was found to attenuate pathway of Aβ induced ROS production and blocked influx of calcium decreasing occurrence of apoptosis amongst neurons. More recently a 2007 study evaluating the effects of inhibiting ROS production by polymorphonuclear leukocytes and formation of oxidative stress in hypertensive rats used the anti-hypertension drug, Benidipine a dihydropyridine or L-type calcium channel blocker with antioxidant properties to reduce oxidative stress.4 The use of this hypertension drug as a therapeutic intervention paralleled the results of the study conducted by Ekinici in 1999 in which L-calcium channels were the target site for attenuate Aβ pathology. Similar to AD, oxidative stress caused by ROS accumulation is a problem in hypertension. Findings showed that Benidipine suppressed ROS production in the polymorphonuclear leukocytes. In the stroke prone hypertensive rats the drug partially inhibited intracellular Ca2+ elevation, protein kinase C activation and NADPH oxidase activation involved in Aβ pathway.1 These studies suggests that perhaps a pharmacological approach would be most effective that targets the sites initially responsible for ROS generation and calcium influx induced by the presence of Aβ.1,2,3

Similarly Azelnidipine, a calcium channel blocker and drug commonly used to treat hypertension and also part of the dihydropyridine group, recent studies have suggested evidence proposing the drug promotes an anti-inflammatory response that reduces levels of ROS in various types of cells.5 In Dr. Naito’s 1998 study L-calcium channels were targeted with Azelnidipine and a MAP kinase inhibitor PD98059. There was a decrease in MAP kinase-mediated phosphorylation of membrane-associated proteins and reduced phosphorylation of cytosolic proteins. The decrease in protein kinase activity in turn leading to reduction
in amyloid beta induced accumulation of calcium, reactive oxygen species, and apoptosis. Aβ deposits and neurofibrillary tangles often stimulate an inflammatory response in Alzheimer’s brain. Based on the later findings of Naito’s 2006 study he found that TNF-α greatly enhanced intracellular ROS in endothelial cells, but Azelnidipine inhibited these enhancements likewise inhibiting endothelial inflammatory responses. Komoda further questioned Azelnidipine anti-inflammatory properties adding to Naito’s earlier studies. He demonstrates the possible anti-inflammatory properties in vascular inflammation for Azelnidipine. An in vitro study was done with human leukocytes the results showed a decrease in IL-6 and IL-8 cytokine levels and oxidative stress. Although this particular study focused on vascular inflammation the findings are applicable to the inflammatory response in AD. Both cytokines IL-6 ad IL-8 are present in the inflammatory response that occurs during Alzheimer’s pathogenesis. Interleukin-6 has been observed to induce Alzheimer-type phosphorylation of tau protein. Aβ-induced tau phosphorylation is mediated by the activation of various kinases such as MAPK and p38.

Despite the extensive research that has been conducted concerning the mechanisms of Aβ signaling pathway that causes Alzheimer’s pathogenesis. There is still a great gap in the literature with many still unsure of what initiates and drives the process that ultimately cause neurodegeneration. The study proposes Azelnidipine could potentially be used as an AD therapy to affect Aβ-induced oxidative and inflammatory pathways.

MATERIALS AND METHODS

Materials: Dulbecco’s Modified Eagle Medium (DMEM), Phosphate-buffered saline (PBS), penicillin-streptomycin (PS), 0.25% Trypsin-EDTA, Hoeschst 33258, pentahydrate (bis-benzimide) (MW 623.96 (H3569), 10% Sodium Dodecyl Sulfate (10% SDS) were purchased from Life Technologies (Grand Island, NY, USA). Ham’s F-12 was purchased from Crystalgen (Commack, NY, USA). (10X) Tris-buffered saline (TBS), 10x Tris/Glycine Buffer, 10x Tris/Glycine/Sodium Dodecyl Sulfate Buffer, 30% Acrylamide/bis solution (30%/AA/bis), 1.5M Tris, 0.5 Tris, Tween 20, 2x Laemmli Sample Buffer, and Immuno-Blot PVDF Membrane for protein blotting were purchased from Bio Rad (Hercules, CA, USA). Fetal bovine serum (FBS) and Dimethyl Sulfoxide (DMSO) were from Sigma Life Science (St. Louis, MO, USA). Bovine serum albumin (BSA) Methanol, and Glycerol were from Fisher Scientific (Hampton, New Hampshire, USA). 2-Mercaptoethanol (β-Me), Tetramethylthelylenediamine (TEMED), and 10% Ammonium Persulfate (10%APS) were from Thermo Scientific (Rockford, IL, USA). Milk powder was purchased from Applichem Inc. (St. Louis, MO, USA). Rabbit polyclonal cPLA2 and phosphorylated-cPLA2 (Ser505) antibodies, Mouse p44/42 MAPK (Erk1/2) (Ser217/Ser218) and p38 MAPK (Thr180/Tyr182, Tyr180/Thr182) antibodies, Phospho-p44/42 MAPK (Thr202/Tyr204) (97G2) Rabbit mAb antibody, and Anti-Rabbit IgG (H+L), (Fab')2 Fragment (Alexor Fluor 488 Conjugate) were purchased from Cell Signaling Technology (Beverly, MA,USA). NF-kB p65 (C-20): sc-372 and E-Selectin (H-300): sc-14011 were purchased from Santa Cruz Biotechnology INC. (Dallas, Texas, USA). Beta - Amyloid 1-42, Human (Aβ1–42) was from Anaspec (Fremont, CA, USA). Mouse epithelial cells, bEnd.3 (ATCC CRL-2299) was purchased from American Type Culture Collection (Manassas, VA, USA).

Cell culture: The mouse epithelial cells (bEnd.3) were maintained in a CO2 humidified incubator at 37º C. DMEM culture media containing 10% FBS and 1% PS was fed to cells every 48 hours. Once reached 80-100% confluency cells were subcultured in a flask. For subculture cells were washed twice with PBS, and then incubated for 2-3 minutes with 0.25% Trypsin-EDTA at 37ºC. DMEM culture media containing 10% FBS and 1% PS were added to cells to stop Trypsin-EDTA reaction. The bottom of the flask was rinsed with medium to remove still attached cells. Cells were seeded into 35mm dishes using 1:9 or 2:8 cell dilutions according to experiment.

Preparation of oligomeric Aβ1–42: Aβ1–42 oligomeric form was prepared according to the protocol described previously by Dahlgren et al., 2002. Briefly, 2 μl of DMSO was added directly onto the abeta film at the bottom of the tube. The tube was centrifuged and was sonicated for one minute. Then 98 μl of ice-cold Ham’s F-12 was added directly to the tube of Aβ. The solution was vortexed, centrifuged, and then sealed with parafilm and placed in 4ºC for 24 hours prior to use. Each tube of Aβ treats two dishes at a concentration of 5 μM abeta. For treating dishes put 100 μl of Aβ solution in a 15ml centrifuge tube with DMEM, 1900 μl of media for each tube of Aβ. Treat each dish with 950 μl of Aβ and DMEM solution.

Azelnidipine drug preparation: Cells were treated with 20nM Azelnidipine. Measure a small amount of Azelnidipine and add to it 1ml of DMSO (solution A). Add 10 μl of solution A and 990 μl of DMEM into a separate tube. Solution was further diluted to a final concentration of 20nM and treated each dish with 2ml of final solution.

Western Blot: Passage 23-30 bEnd.3 cells were cultured in 35mm dishes until 90% confluent. Cells were starved for at least 30 minutes before treatment with 20nM Azelnidipine for four hours, followed by treatment with oligomeric Aβ1-42 for two hours. Then cells were washed with PBS for twice and adding 300 μl Laemmli buffer for cell lysis. Samples were collected into 1.5 ml Eppendorf tubes and prepared by sonication, mixing with 7.5 μl 2-Mercaptoethanol and boiling for 5 minutes for each tube. Equivalent volume (e.g. 40 μl) of protein lysate samples were resolved in 8% SDS-PAGE gel. After electrophoresis, proteins were transferred to PVDF membrane. Membranes were blocked with Tris-buffered saline, pH 7.4, with 0.1% Tween 20 (TBST) containing 5% BSA or 5% non-fat milk for 1 hour at room temperature for phosphorylation ERK, cPLA2 and ERK, cPLA2 respectively. The blots were reacted with rabbit phosphorylated p44/42 MAPK (Erk1/2) (Thr202/Tyr204) (1:1000 in 5% BSA), rabbit phosphorylated cPLA2 (Ser505) (1:1000 in 5% BSA) or mouse p44/42 MAPK (Erk1/2) (3A7) (1:2000 in 5% BSA), rabbit cPLA2 (1:1000 in 5% BSA) antibodies at 4 ºC overnight. After washing with TBST, they were incubated with anti-rabbit (1:4000) or anti-mouse (1:5000) IgG HRP-linked secondary antibody for 1.5 hours at room temperature. The blots were then washed with TBST for three times, bands were visualized by using Super Signal West Pico or Femto Chemiluminescent detection reagents.

Immunofluorescence Microscopy: bEnd.3 cells over passage 30 were grown on coverslips until 50-70% confluent. After treatment (20nM Azelnidipine for 4 hours followed by 5μM...
Aβ for 2 hours or 100ng/ml TNF-α for 30 minutes), cells were fixed immediately using 3.7% paraformaldehyde solution for 15 minutes and then permeabilized with 0.1% Triton X-100 for 5 minutes. 5% BSA in PBS was applied to cells for 1 hour to block non-specific binding. NF-κB in the cells was labeled with its rabbit anti-mouse primary antibody (1:100 in 1% BSA) at 4°C overnight, after that, anti-rabbit secondary antibody conjugated with Alexa Fluor 488 (1:1000 in 1% BSA) was employed for labeling. Cell nucleus was labeled by 2 μg/ml Hoechst 33258 for 8 minutes. Between each steps, cells were washed with 1% BSA. 40 images were acquired for each coverslip; background was taken with a blank coverslip without cells grown. Data was analyzed by showing the ratio of the intensity of cell nucleus to the whole cell and then compared each groups with control group.

For E-selectin experiment, the procedures are the same with NF-kB immunofluorescent experiment. But cells were treated with 1μM Aβ for 12 hours instead of 5μM for 2 hours. And the data was analyzed by calculating the average intensity of each cell and compared each groups with control group.

**Statistical Analysis:** Data are presented as mean ±SD from at least three independent experiments. Comparisons between groups were made with one-way ANOVA, followed by analysis with KaleidaGraph software. Comparison between two groups was made with unpaired t test. Values of p<0.05 are considered statistically significant.

**RESULTS**

To examine if the hypertension drug Azelnidipine is capable of attenuating the Aβ-induced cellular pathways of oxidative stress and inflammatory responses shown to alter endothelial functions western blot analysis was performed to observe the phosphorylation of the intracellular signaling molecule Erk1/2, and immunofluorescence microscopy was employed to measure the translocation of protein complex, NF-kB into the nuclei.

**ALP suppresses activation of ERK induced by Aβ:** Aβ42 is known to induce MAPK/ERK downstream signaling pathways which include ERK activation.14 In our western blot analysis we observed that Aβ42 induced the activation of both types of ERK p44 and p42. We examined the phosphorylated ERK in regards to the total ERK. Higher values indicated greater induced activation of ERK. When we treated with 20nM Azelnidipine for 4 hours prior to our 5μM Aβ treatment we observed a significant decrease in the phosphorylation of both types of Erk as indicated in Figure 1 and 2. Upon examination of the effect of ALP alone there was found to be no significant difference in the phosphorylation of both types of ERK which was similar to our control in both cases of ERK p44 and p42.

**ALP suppresses Aβ-induced translocation NFkB to nuclei**

Inactive NF-kB lies outside of the nuclei and Aβ induces the activation of the transcription factor causing translocation to nuclei. Immunofluorescence microscopy was employed to measure the translocation of NF-kB into the nuclei. The nucleus and NF-kB were stained for. Figure 3a. shows the NF-kB in the nuclei in regards to the total NF-kB of the cell. As expected our group treated only with Aβ for 1 hour experienced induced translocation of NF-kB to the nuclei. Cells treated with TNF-α for 30 minutes were used as a positive control. TNF-α will induce the translocation of NFκB into the nucleus. We compared the cells treated with ALP for 4 hours prior to treatment with Aβ to both our groups treated only with Aβ and TNF-α our positive control. We observed a significant decrease in the translocation of NF-kB to the nuclei when cells were pretreated with ALP. Figure 3b. shows our immunofluorescence images that correlate to our graph depicted in Figure 3a. The cell treated with Aβ only has evident translocation of NF-kB into the nuclei similar to what we observed in our positive control TNF-α treated cell. The cell treated with both ALP and Aβ experienced some NF-kB translocation as compared with our control, but significantly less than both our Aβ and TNF-α treated cells. We also tested the effect of ALP alone and found there were no significant induced changes to the nucleus.

**Figure 2** ALP suppresses activation of ERK p42 induced by Aβ. * compared with Control group; o compared with Aβ group * P≤0.05, ** P≤0.01, ***P≤0.001

**Figure 1** ALP suppresses activation of ERK p44 induced by Aβ. * compared with Control group; o compared with Aβ group * P≤0.05, ** P≤0.01, ***P≤0.001
DISCUSSION

In Aβ-induced oxidative pathway, NADPH oxidase is activated to produce ROS. ROS, in turn, activate MAP kinases, such as p38, ERK, and JNK. Activation of MAP kinase results in activation of cytosolic phospholipase A2, leading to alterations of membrane properties and mitochondrial dysfunction. While the Aβ-induced inflammatory pathway, activation of NF-kB is involved, leading to elevated expressions of P and E-selectins at the cerebral endothelial surface. We were able to support our initial hypothesis and determine that ALP is able to suppress Aβ-induced oxidative and inflammatory pathways that cause alterations in cerebral endothelial functions. This was evident by the decreased phosphorylation of Aβ-induced ERK as well as the decreased translocation of Aβ-induced activated NF-κB into the nuclei. Our findings correlated to previous studies such as Dr. Naito’s 1998 study which observed decreased Aβ-induced protein kinases activity, and his later 2007 study which found that Azelnidipine inhibited TNF-α enhanced intracellular reactive oxygen species and inflammatory response in endothelial cells. The results of the experiments shed further insight into the Aβ-induced cellular pathways and expressed the potential of Azelnidipine having application as a therapeutic strategy to treat AD. This was evident by the Aβ-induced activation of ERK, as indicated by increased phosphorylation of ERK was suppressed by ALP. In addition to the Aβ-induced activation of NF-kB, as indicated by increased translocation of NF-kB to nuclei was suppressed by ALP. There are many steps in both Aβ-induced oxidative and inflammatory pathways. Further research must be done to test if Azelnidipine is able to suppress other steps in Aβ-induced cellular pathways.

ACKNOWLEDGEMENTS

Special thanks to Tao Teng, Yawen Ni, and other Lee lab members.

This project was funded by the Alzheimer Association Grant NIRG-06-24448, NIH Grant 1P01 AG18357, R21NS052385, 5R21AG032579, and the Ronald E. McNair Scholars Program.

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**ABSTRACT**

**Objective:** Shed light on the role that health literacy plays in the physical activity levels of patients with knee osteoarthritis.

**Methods:** Ten participants 40 years or older recruited from a pre-existing study on pain, fear, and harm were interviewed. Interviews were analyzed by qualitative methods for themes to explain health literacy issues present in the participants’ experiences.

**Results:** Participants coped with their knee pain in different ways. They believed that physical activity was either good for their knee OA or caused further harm to their knee OA.

**Conclusion:** Participants showed a range of understanding regarding their knee OA pain and physical activity.

**Implications:** The study provides insights about the concepts of health literacy and understanding how patients are interpreting their health related information.

**INTRODUCTION**

Health literacy is defined as the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions. Health literacy measures five skills: reading, writing, listening, talking, and numeracy. Health literacy is context dependent, which means it is interpreted differently depending on the situation (“Improving health literacy,” 2010). In order to determine health literacy skills in an individual a health professional must use techniques that would help in discovering the level of health literacy that the individual possesses. Evaluating health literacy is important because it can be a stronger predictor of an individual’s health than age, income, employment status, education level, or race. Individuals with low health literacy usually have a higher risk of death, visit emergency rooms more often, and are hospitalized more frequently. (Volandes & Paasche-Orlow, 2007)

Osteoarthritis (OA) is the most common type of arthritis and it affects middle-aged to elderly individuals. OA is characterized by the degeneration of cartilage, which is the tissue that covers the ends of bones where they meet to form a joint. It is a chronic condition, which causes bones to rub against each other, causing stiffness, pain and loss of joint movement. OA can have mild affects and disturb people’s day-to-day life or it can cause serious pain and disability causing a change in people’s life-styles.

It is important to understand the outcomes that are present in populations with low health literacy because they are always associated with higher health costs. Health professionals would benefit from discovering the association between health literacy and the role it has on their patient’s activities because it would
help them to understand patient behavior and their health outcomes ("Osteoarthritis," 2011). Patients with low health literacy have the inclination of adopting poor health behaviors so it can be inferred that individuals with low health literacy may take part in activities that are more damaging to their health than it is in aiding it.

The goal of this study is to shed light on patients’ physical and cognitive behaviors and how it is correlated with limited health literacy. Furthermore, to ultimately increase health professionals’ communication toward their patients and improve health literacy skills. The aims of this study are to document the lived experiences of patients with knee osteoarthritis and to first, determine if their narratives present high or low health literacy skills, which then will be a cursor to find the commonalities between the patients. Second, to document the lived experiences of patients with knee osteoarthritis and to determine if the commonalities found are related to the decrease of physical activity.

The causes of decreased physical activity can be associated with low levels of health literacy. The following articles reviewed are related to health literacy and decreased physical activity with a common goal: to identify barriers between health professionals and patients in regards to health literacy practice; identify why patients avoid physical activity. The theme presented in the first two articles is related to decreased physical activity because of common misconceptions in society; belief that physical activity causes further damage to the body, which is a health literacy issue. The following two articles are directly related to health literacy issues; low patient-perceived empathy and its affect on health literacy skills and the benefits and techniques of improving health literacy skills within patients as well as health professionals.

Hendry, Williams, Markland, Wilkinson, and Maddison (2006) performed a study that examined the views of primary care patients with osteoarthritis (OA) of the knee towards exercise. The objective of this study is to explore factors that determine the acceptability and motivation to exercise and to identify common barriers that could limit physical activity that could be addressed in primary care consultations. Hendry et al. (2006) used a 45-60 minute semi-structured recorded interview to collect data from each of 22 participants diagnosed with OA of the knee. The participants selected for the study represented the geographic and socio-economic diversity of the North Wales region. During the interviews, participants were encouraged to express their views about the definition of ‘exercise.’

The inclusion criteria used throughout the interview process was to give the participants a broad definition of ‘exercise’ as “attending a gym, brisk walking, cycling, or participating in sports as well as ‘therapeutic exercises’ prescribed by a health professional.” (Hendry et al., 2006, p. 559). Additionally, ‘physical activity’ was broadly defined as “active work, housework, gardening, or hobbies.” (Hendry et al., 2006, p. 559). Following each recorded interview, Hendry & Williams (2006) fully transcribed the recordings and coded the interviews into categories, themes, and sub-themes. Subsequently, the transcripts were transferred to a computer program that facilitated “the management and indexing of the qualitative data.” There were three main categories that emerged from the interviews that could explain exercise behavior. The categories were ‘physical capacity’ including knee-specific limitations to exercise or general limitations to exercise; ‘beliefs about exercise’ including personal experience with exercise or receiving exercise advice; and ‘motivating factors’ such as enjoyment, social support, or setting exercise as a priority. The types of exercise behaviors that depended on the three main categories were identified as ‘long-term sedentary’, ‘long-term active’, ‘retired from exercise’, and ‘converted to exercise.’ Hendry et al. (2006) found that the participants that had stopped exercising did so because of their OA symptoms, their nonexistent exercise habits, and their belief that exercise was damaging to their joints. Hendry and colleagues (2006) also found that the participants that started to exercise did so because their worsening symptoms and disability encouraged them to improve their health. It was concluded by Hendry et al. (2006) that patients who are sedentary or retired from exercise could be advised that exercise would benefit OA of the knee. Primary care clinicians should emphasize the meaning of words such as ‘wear and tear’ when discussing with OA patients the importance of exercise in regard to OA; this would avoid confusion and avoid decreased motivation to exercise. Further research was needed to determine whether the prescribing of exercise and gym referral are the best intervention for the participants in the ‘long-term sedentary’ and ‘retired from exercise’ type of exercise behavior group.

Mackichan, Adamson, and Gooberman-Hill (2013) investigated the reasons why older people adjust their activity levels when living with chronic pain; pain lasting three or more months. 31 people who had chronic pain between the ages of 67 and 92 were interviewed for 45 minutes to 2 hours. Participants were asked to discuss their pain experiences and behaviors in detail concerning the topics of: onset and trajectory of chronic pain, illness action, views on the solubility of pain and the future. In addition to the interview topics, the researchers helped the participants write a timeline for the key events of their life history, in which they called a ‘life grid’ (Mackichan et al., 2013, p. 703). The data on the recorded interviews were analyzed and transcribed before being imported into a computer software that helps manage data and facilitate coding. A central category emerged within the participants’ data, ‘living within your limits,’ which was coded as the restriction of activity. The participants had altered or reduced their social and physical activities and Mackichan et al. (2013) found two key concerns that emerged: ‘safeguarding function’ and ‘avoiding medical interventions.’ ‘Safeguarding function’ can be described as the participants’ desire to avoid or restrict their activity level because of fear of potentially triggering pain. Their goal is to live their life independently for as long as possible and they fear a decline and loss of autonomy. ‘Avoiding medical interventions’ can be described as to how the participants interpret conventional treatments. They see prescription pain medication and surgery as “the very last resort” option (Mackichan et al., 2013, p. 704). They avoid or restrict activities that could trigger pain to avoid medical intervention. Activity restrictions were rationalized as normal in older age; participants believed impairments were legitimate and of an acceptable level of functioning. In contrast, other participants demonstrated significant efforts of perseverance with activities and resistance in pain. However,
they still experienced unavoidable activity restrictions and frustration as a result of physical limitation that impacted their social activity. (Mackichan et al., 2013, p. 705). Mackichan et al. (2013) found that decreasing physical activity and social participation were described as an inevitable consequence of pain. They found that “…self-imposed restriction of activity is a rational element of older people’s attempt to prevent further pain, associated disability, and subsequent medical intervention” (Mackichan et al., 2013, p. 707).

Chu and Tseng (2013) investigated the effect of patient-perceived empathy on the relationship between health literacy and understanding of preoperative information. The objective of the study was to demonstrate that by improving physician-patient empathy skills, patients could overcome negative consequences associated with limited health literacy. 144 patients visiting an inpatient orthopedic clinic to receive total hip and knee replacement medical services participated in the 2-month study. The first set of data collected was on perceived empathy and patient understanding of when the patient and physician had their first interaction and exchange of the medical center’s standard health education materials. After the patient’s surgery, a trained researcher obtained health literacy, perceived empathy, and preoperative understanding of information characteristics from a face-to-face survey once the patient was willing to answer questions personally. Health literacy was measured using a Rapid Estimate of Adult Literacy (REALM) test. This test measures a patient’s ability to correctly read and pronounce 66 common medical terms. The score given depended on if the patient pronounced the term well; receiving 1 point or not pronouncing the term well; receiving 0 points. A higher score represented greater health literacy. Perceived empathy was measured using the Barrett-Lennard Relationship Inventory (BLRI), which is a 16-item empathy understanding subscale. The items are scored on a 5-point Likert scale with the highest score being 80; higher scores represented more empathy perceived by patients (Chu and Tseng, 2013, p. 2). Understanding of preoperative information was measured using an 18-item Preoperative Information Understanding Scale (PIUS). Three areas were assessed including: operation information, anesthesia information, and nursing instructions information. The responses were scored numerically from 0-3; 0 meaning information was not provided and 3 meaning information was provided and well understood. A higher score represented a better understanding of preoperative information. A statistical analyses using the computer program Statistical Package for the Social Sciences (SPSS) was used to attain results from the data collected. Chu and Tseng (2013) found that regardless of a patient’s low level of health literacy, patients would be able to understand more preoperative information as long as their physicians express more empathy. Furthermore, they found that when physicians express low empathy it negatively impacts a patient’s understanding of preoperative information without regard of their health literacy level. Chu and Tseng (2013) concluded that improving physician-patient empathy skills could be beneficial in helping to overcome the negative consequences associated with limited health literacy capabilities (Chu and Tseng, 2013, p. 5). Chu and Tseng (2013) stated that future studies are needed to replicate their findings using other measures of health literacy and perceived empathy because different measures may produce different results.

Levasseur and Carrier (2010) discuss the importance of integrating health literacy in rehabilitation practices. The authors stated that the majority of rehabilitation professionals do not know enough about health literacy and they believe their study will help rehabilitation professionals actively contribute to improving and promoting health literacy in their patients. Levasseur and Carrier (2010) reviewed 1079 rehabilitation articles by using the following databases: MEDLINE, OTDBASE, CINAHL, AMED and MANTIS. They used the methodology of scoping studies, which is used to “examine the extent, range, and nature of publications in a particular field” (Levasseur and Carrier, 2010, p. 758). Furthermore, they used a combination of keywords including ‘health literacy’, ‘rehabilitation’, ‘physical therapy’, ‘occupational therapy’ and ‘health promotion’ from the year 1980 to 2008 in order to identify research gaps in each article. Levasseur and Carrier (2010) found that of the 1079 articles, only 17 (1%) articles included the key words ‘health literacy’ and ‘rehabilitation’, ‘physical therapy’, or ‘occupational therapy’ altogether. Of the 17 articles, only 10 of them addressed health literacy and rehabilitation in sufficient detail but did not discuss specifically the importance of integrating health literacy into rehabilitation practice. After reviewing all 1079 articles, Levasseur and Carrier (2010) establish that health literacy is of general importance, the articles presented factors associated with low health literacy levels, and they provided information that link health literacy to rehabilitation. Levasseur and Carrier (2010) stated that health literacy is important because it not only impacts individual health but it also has economic, cultural, and social consequences. The authors go on to explain the factors associated with low literacy levels including personal limiting factors like low levels of education; environmental obstacles like social stigma; and the interaction between the individual and the environment like motivation, compliance, and social participation and skills (Levasseur and Carrier, 2010, p.760). Levasseur and Carrier (2010) conclude that interventions conducted by rehabilitation professionals can be conducive because of timing issues and professional knowledge. Rehabilitation professionals treat their patients at a time where their patients’ are going through an adaptation process, which makes them more susceptible to listen to explanations concerning their health problems. At this time they can take action to optimize their patients’ abilities and reduce limited health literacy. Rehabilitation professionals can act as health educators and can stress health promotion to their patients to include health literacy. A limitation to this study includes further research on the determinants of health literacy, patients’ habits to accessing health information, and the effectiveness of innovative interventions to improve health literacy. Another limitation is that the authors’ opinions were based on foundations that may have influenced their study (Levasseur and Carrier, 2010, p.761).

Although health literacy wasn’t mentioned in the first two articles there are indirect health literacy issues that can be found within the results and discussion of the studies. Hendry et al.’s (2006) study mentioned that individuals’ beliefs about exercise influenced their decision to exercise or not exercise. Some individuals believed that exercise didn’t help their knees
at all so they would restrain from any kind of physical activity. Others were influenced by the vague advice given to them by their physicians. According to Chu and Tseng (2013), when physicians expressed more empathy, their patients would have a better health outcome. Similarly, individuals believe that when they feel pain it is an indicator to decrease physical activity. Mackichan et al. (2013) found that patients’ decision to retire from exercise or restrict themselves from social activities requiring physical activity stemmed from a rationalization that they were old. Mackichan et al.‘s (2013) study demonstrated that social stigma is a limiting factor of health literacy, which was an important finding related to Levasseur and Carrier (2010). A common theme within all the previously reviewed articles is that there is not a lot of research on how to integrate health literacy into health practices. According to Levasseur and Carrier (2010), literature on health literacy needs to be enhanced in both quality and quantity. Studying the effect of health literacy in the decrease of physical activity in knee osteoarthritis patients will contribute to the literature on health literacy and will uncover further issues that could be the basis to create innovative and proactive initiatives toward health literacy improvement.

**METHODS**

The present study is part of a larger study clarifying the relationships among physical activity and activity-related pain, fear, and harm and increase physical activity in older patients with chronic musculoskeletal pain. The Institutional Review Board (IRB) number for the pre-existing study is 1202036 and is being conducted by Erin A. Dannecker, Ph.D.

The study sample included 10 mid to older adults OA knee patients. Inclusion criteria included; 40 years or older, community dwelling, diagnosis of knee OA, and healthcare provider recommendation of exercise program to treat knee pain. Exclusion criteria included; unstable medical conditions, hip/knee replacements, wheelchair dependence, and regular substance abuse within the past 6 months. A score lower than 18 out of 22 on the telephone version of the mini mental state examination (Roccaforte, et. al, 1992.)

Participants were interviewed in person and asked about their experiences coping with OA related knee pain and physical activity (see appendix for interview instrument). A trained research assistant transcribed the participant narratives verbatim. I used a thematic analysis technique to search for health literacy related issues faced by the participants. Thematic analysis is a qualitative research technique in which the participants’ own words are used to explore and document their lived experiences. This research method was chosen in order to document the themes that emerged from that data and most accurately capture that patients lived experience. Ten participant narratives were analyzed to find the role that health literacy plays in the decrease of physical activity among patients with osteoarthritis. The main theme was activity continuance despite pain in the knee, and the two subthemes were pain interpretation and knowledge of pain, personal experience with pain, influence from self and others. The major theme presented throughout the narratives explained why despite knee pain during certain activities, the majority of the participants continued to be active while doing chores around the house, work related activities, exercise, etc.

Table 1 depicts the relationship between the main theme, subthemes, categories, and subcategories throughout the narratives.

![Table 1. Themes and categories found in patients with osteoarthritis.](image)

**RESULTS**

Depending on the participant’s pain interpretation and their health literacy skills, participants coped with their knee pain in different ways. Participant’s Knee pain was interpreted as normal pain, good pain, or bad pain. Normal pain was described as how knee pain usually felt throughout a typical day. When participants described normal pain they said it felt “dull” and “achy”. A participant said: ‘There’s always like that dull ache that I just kind of ignore but depending on what I’m doing and how, you know, how much I’m doing, it can get a little more’ (No. 39). When asked about coping, more than half of the participants claimed to alleviate the normal pain via over the counter medication. One participant said, ‘…when [the pain] gets to be more intense than probably a 4, then a lot of times I'll take an ibuprofen’ (No. 404). Another stated that when he/she feels that the pain is too much he/she will take an Aleve or slow down (No. 39). A smaller group of the participants explained that they choose to treat their normal pain with prescribed medication: participant No. 110 described needing a ‘knee injection’ when nearing or surpassing normal pain. Participant No. 404 stated, ‘…occasionally it gets…bad enough that I take a Vicodin.’

Good pain was described as being dependent upon a situation; the association between pain and a good situation is what makes it good. Only seven of the ten participants said they had experienced good pain. Out of the seven participants, five of them said that good pain was different from normal pain; two of the participants said good pain and normal pain were the
same. The participants described good pain as having a positive outcome following a more intense pain than usual. A participant said: ‘...there have been a couple of times when I’ve fallen... It feels like there’s scar tissue that gets torn then it feels like with that it gets less restrictive and I’ve got more flexibly after that sharp pain and that’s a pretty sharp pain’ (No. 335). The majority of participants experiencing good pain coped by ‘listening’ to their body and taking action only when the pain was determined to be more than bearable. When asked specifically about coping with their knee pain, a participant explained ‘...I don’t usually take anything...if you mask all the pain, that’s when you get hurt’ (No. 39).

Bad pain was pain that the participant considered harmful or that lasted longer than normal pain or good pain. The majority of the participants described bad pain as being related to a person’s mentality, whether or not the pain made them feel happy or sad or had a negative or positive outcome. A participant said: ‘...if it’s good pain I’m feeling happier. If it’s bad pain... it starts to get to me. I mean it affects my mood... what I want to get done. If it’s really bothering me I am grumpier’ (No. 447). Another participant said: ‘...with the good, when it has happened, it’s increased my range of motion that I’m comfortable with. ...With the bad, just hurts more. It hurts and nothing positive comes from it’ (No. 335). When questioned about coping with bad pain, most of the participants described a situation in which they immediately stopped the activity they were doing to rest and ice their knee. ‘I sat down and put ice on it,’ said participant No. 39. Another participant said that he/she ‘Just get[s] off. …get off my feet’ (No. 447).

**Knowledge of pain, personal experience with pain, influence from self and others**

The experiences that the participants held concerning their knee pain and physical activity were factors that contributed to the development of high or low health literacy thoughts, ideas, habits, and beliefs. Depending on the participants’ context of pain and their health literacy skills, participants believed that physical activity was either good for their knee osteoarthritis or caused further harm to their knee osteoarthritis.

**Knowledge of pain.**

Participants who had experienced pain during physical activity such as walking mentioned that walking helped decrease their knee pain. When a participant was asked if his/ her knee pain had ever increased the difficulty of walking, he/she responded,

‘At work I try to take the breaks and then walk around the building for 10-20 minutes total a day I also walk from the parking garage to work. ...I wouldn’t really say I like or dislike walking. But walking I feel like is something I need to do if I don’t want more... more pain, yeah. ...Usually they are pretty short walks that it doesn’t bother the knees and its not like rough surfaces, which may make a difference. Basically I walk on a flat surface and avoid climbing steps.’ (No. 200)

Six out of the ten participants that felt they were knowledgeable about the relationship between pain and physical activity believed that physical activity was good for their knee pain. Participant No. 200 mentioned, ‘...it seems at this point it is like the early stage of the problems that I am experiencing and I am trying to do the right thing. In terms of like exercise more to prolong the degeneration since I heard that it is pretty much is degenerative.’ Four out of the ten participants believed that physical activity was damaging to their knee and further increased their knee pain. These participants made it clear that they usually avoid doing any kind of physical activity in order to prevent further injury to their knee. Instead they prefer alternative methods of coping with their knee pain to include vising a physician to receive treatment and avoiding physical activity completely. Participant No. 110 stated that he/she would wait until his/her knee was fairly painful until he/she decided to go to the doctor for an injection of “Synvisc,” which he/ she received every six to twelve months to treat her knee pain. Participant No. 404 stated that he/she couldn’t stand on his/her feet for very long because it wore him/her out. When asked what he/she would usually do to cope with increased difficulty doing an activity he/she responded, ‘by not doing the activity.’

**Personal experience with pain.**

The experiences the participants had with their knee pain were found to uncover emotions of fear and embarrassment. Eight out of the ten participants experienced emotions of fear and embarrassment. The emotions they faced were caused by their inability to perform physical activities to the extent that they wanted to perform them. Sometimes the participants were forced to quit or stop the activities they were involved in, in order to prevent discomfort, increased knee pain, or damage to their knees. Participants felt embarrassed in front of family, friends, and even strangers. They felt fear when their safety and health were questionable. When asked to describe an instance of when participant No. 39 felt embarrassed because of difficulty being physically active, she felt that going on a walk with her husband and son was humiliating,

‘...I couldn’t keep up with everyone else and felt like I was dragging them behind or they felt like they were with an old woman.’

Similarly, participant No. 200 replied,

‘I feel embarrassed because I tripped. ...And now I have to explain to someone what happened.’

When discussing fear, participants were asked if knee pain had ever increased the difficulty of doing physical activities, participant No. 404 replied, ‘I’m so afraid my knee is going to give out while I’m carrying them you know and I’d hate to fall on one of those babies or to drop one of them you know.’

**Influence from self and others.**

Participants seemed to obtain their knowledge concerning pain interpretation, pain treatment, and certain terminology and beliefs regarding osteoarthrits from their doctors, family members, instructors, and themselves. One participant relied on her husband’s personal involvement with knee osteoarthritis and she made her decisions and assumptions based upon his experiences. Her husband had five operations on his knees and two partial knee replacements so she instantly assumed that all pain is bad and therefore, had restricted herself from any type of
physical activity (No. 159). Another participant was a nurse so the influence came from her own experience. She was asked if she had ever been uncertain as to whether her knee pain was good or bad. She replied, ‘Being a nurse I can kind of tell what my limit is and when it’s time to quit. If I ever questioned it I would definitely have it looked at’ (No. 39). She trusted her own instincts but not enough to make her own decision to whether or not her knee pain was good or bad. She was implying that she would have a physician diagnose her.

DISCUSSION

This qualitative study examined the lived experiences of patients with knee osteoarthritis to determine their health literacy skills and the relationship it had with the decrease of physical activity. Health literacy was measured by identifying emerging themes from the narratives of each participant. The main theme that was evident throughout the narratives was that when participants experienced knee pain while doing a physical activity, they would choose to continue doing the activity despite their pain. This main theme was further explained by finding how the participants interpreted their knee pain, what knowledge they had regarding knee pain, what personal experiences they had with knee pain, and the influences that they had from their family, friends, peers, and strangers related to knee pain.

Pain interpretation.

There were three categories that emerged from the narratives that could explain pain interpretation. The categories were normal pain, good pain, and bad pain. When interviewed about experience with normal pain, 60% of participants alleviated their pain by taking over-the-counter medication and 10% alleviated their pain by taking prescribed medication. From the 60% that coped by taking over-the-counter medication, only 17% also coped by doing physical activity and another 17% also coped by avoiding physical activity. Since the participants that took prescription medication to alleviate their pain never mentioned that they would do or would not do physical activity, it can be inferred that the majority of participants avoided prescription medication as well as physical activity. In fact, a total of only 40% of participants alleviated their pain by doing physical activity. The avoidance of prescription medication and physical activity was caused by the participants’ beliefs that normal pain is not a significant reason to change their activity level in order to treat their disease. It is implied that the participants refused to take prescribed medications because they felt that they could treat themselves without professional help. These findings were similar to Mackichan, Adamson & Gooberman-Hill’s (2013) in that many participants held an aversion to conventional treatments for pain. Their participants saw prescription medication as a last resort to treat pain and restricted or completely avoided physical activity to keep from taking prescription medication.

In the current study, participants described normal pain as knee pain that they felt on a regular basis, whether or not they were doing physical activity. When discussing good pain and bad pain, participants always interpreted their pain as a feeling they got while they were in motion; exercising, playing a sport, taking dance classes, doing yoga, walking from one place to the other, etc. The majority of the participants claimed to have experienced good pain, in which they believed that good pain was different from normal pain and as a manner of coping with their good pain they continued doing physical activity or decreased it slightly to prevent further pain. Only a small group believed that good pain and normal pain were the same as each other, those that did, avoided physical activity completely. When asked about experience with bad pain, all of the participants believed that bad pain was different from normal pain and good pain. Only 10% of the participants said they would resort to physical activity as a manner of coping with their knee pain. The remaining 90% of the participants said that they would cope by getting off their feet and avoiding physical activity completely.

Knowledge, experience, pain.

The knowledge participants had in regards to their knee pain was mainly influenced by their own personal experience with knee osteoarthritis as well as their friends’ and families’ experience. The presence of physical activity that was implemented while participants’ suffered with knee pain was an indication of their health literacy. 60% of the participants believed that doing physical activity was good for their knee osteoarthritis, while the other 40% believed the physical activity only caused more damage to their knees. These findings indicate that most of the participants had the knowledge that physical activity is beneficial for treating their knee pain, but when they were asked how they coped with their normal and bad knee pain they would choose to ignore their knowledge of pain and avoid physical activity. Participants only chose to practice their knowledge when their knee pain was considered good.

When participants discussed their personal experiences with knee pain, 80% of them exhibited emotions of fear or embarrassment when doing physical activity. Their fear and embarrassment was derived from their lack of knowledge concerning pain and physical activity. It was a result of not knowing their limits with physical activity and not knowing if the pain they felt during physical activity was an indication to decrease or stop the activity. Additionally, their embarrassment was due to not being able to perform like they used to; when they were younger or without the disease. Their fear was caused by the thought of inflicting more pain on their knees when doing physical activity. Fear was a way of restricting their activity in order to preserve their functioning thus, causing embarrassment when being inactive around others.

The participants in the study showed a range of understanding regarding their knee osteoarthritis pain and physical activity. For example, one of the participant’s who was struggling with knee osteoarthritis pain decided to limit their physical activity assuming that they would decrease their knee pain. If the participants in the study had been better informed, they would have had more pragmatic expectations of the normal pain, good pain, and bad pain associated with physical activity. Furthermore, the fear and disruption of physical activity could have been avoided if participants were aware of the actual ranges and restrains of their knee osteoarthritis.
CONCLUSION
In this study, health literacy barriers were identified that could be addressed in the health profession population. The detailed descriptions depicting pain interpretation and knowledge of pain could provide health professionals with a basis to create innovative and proactive initiatives toward improved health outcomes. More specifically, the participants in this study demonstrated a range of confidence and knowledge regarding OA knee pain and physical activity. The participants reported experiencing fear related to physical activity and pain. The fear and subsequent disruption of physical activity could have been avoided if they were aware of the actual range and restraints of their knee OA.

IMPLICATIONS
This study had several limitations. First, the data were obtained from a pre-existing study that involved knee osteoarthritis patients but only ten data narratives were collected for the current study. Second, the age and gender of the ten participants were not available for interpretation. Third, there were missing data on two participants. One participant did not have information on bad pain interpretation; another participant did not have information on good pain interpretation. Fourth, only one researcher interpreted the data for this study.

REFERENCES
As a first generation college student, my knowledge about graduate school let alone college was severely limited. However, through the Gates Millennium Scholarship Program, I did learn that there was this thing called graduate school and that I should go but I did not know or understand how to get there.

I started talking to my professors to gain more information about graduate school and they had mentioned encouraged me to apply to the McNair Scholars Program. Following their suggestion, I applied and became a McNair Scholar in 2003, my senior year at Mizzou.

As a McNair Scholar, I entered into what seemed to be a boot camp that was aimed at my individual success as a scholar, ultimately preparing me for graduate school. My McNair mentor, Dr. Michael Mobley, helped me design a research study that linked both of our interests in multiculturalism and counseling. He provided an incredible amount of guidance in quantitative methodologies as well as what it means to be a scholar. He also encouraged me throughout the graduate school search and application process. The McNair Program staff provided ongoing workshops and advice geared towards being successful and thriving in graduate school. Beyond the professional development, the McNair Program provided a community of support among the staff and fellow scholars alike. Everytime I had questions, concerns, or needed to bounce ideas off of someone, my fellow scholars and McNair staff were ready and willing to help. They helped me through the road bumps and celebrated the successes on my journey to graduate school.

Pursuing a master’s degree was a scary and exciting endeavor, especially because I moved even farther away from home. However, once I got in the classroom and began to interact with the professors, I felt like my background and experience in the McNair Program gave me an edge. I not only knew how to read research, but I knew how to engage in scholarly discussion. Quite frankly my love of research is what pushed me to pursue a Ph.D.

As of August 2013, I earned a Ph.D. in Counselor Education from The Ohio State University. I am currently an Assistant Professor and Director of the School Counseling Program at Ball State University, teaching courses focused on social justice and equity in school counseling. Further, I am conducting research concerning Black and Brown students in the educational pipeline, which aligns with my interests that emerged as a part of the McNair Program. I’m confident that my participation in the McNair Program provided me with the necessary skills to thrive in graduate school. The mentoring and connections that I made in the program have extended beyond my time at Mizzou. In fact, I still talk with Dr. Mobley and the Mizzou McNair family to this day.
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2013-2014 McNair Scholars

Back row: NaTashua Davis (Director), Brian Gaffigan, Calandria Frazier, Rafael Cisneros, Jeremy Bloss (Program Coordinator)

Second Row: Shawna Rowe, Constance Gacich, Jennifer Shearin, Ariel Hagedorn, Kayla Henderson, Brandice Carpenter, Maria Oyelola, Darlene Dixon (Program Assistant), Marjory Vazquez (Graduate Assistant)

Front Row: Katerina Rios, Chanell Washington, Gloria Sipakati, Marnae Chamvers, Tiffany Jerrod, Sarah Swartz

Not Pictured: 2014 Summer Scholar Jalisa Shaw